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## MARS: GET A GLORIOUS VIEW

PLUS

An In-depth Review of NexStar's Small Scopes

Bring Astronomy to Your Desktop

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# LX200

**MEADE**

7" • 8" 10" • 12"

## THE TELESCOPE STANDARD OF THE WORLD

With their large object databases, fast slewing speeds, and uncanny pointing precision, Meade LX200's are recommended for those amateurs who intend an extensive program of CCD imaging, astrophotography, or deep-space observing.

**Superb Optics:** With oversize primary mirrors for greater full-field illumination, LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.

**Automatic GO TO Capability:** Meade LX200's place objects **dead-center** in the field of view, first time, every time, to a pointing precision of **2 arc-minutes or better,** or, with Meade exclusive High Precision Pointing, to a precision of **one arc-minute or better.** *Meade LX200's are the only commercial telescopes ever manufactured that automatically GO TO any input R.A. and Dec., or to any object in the onboard database of 64,359 objects, to these levels of precision.*

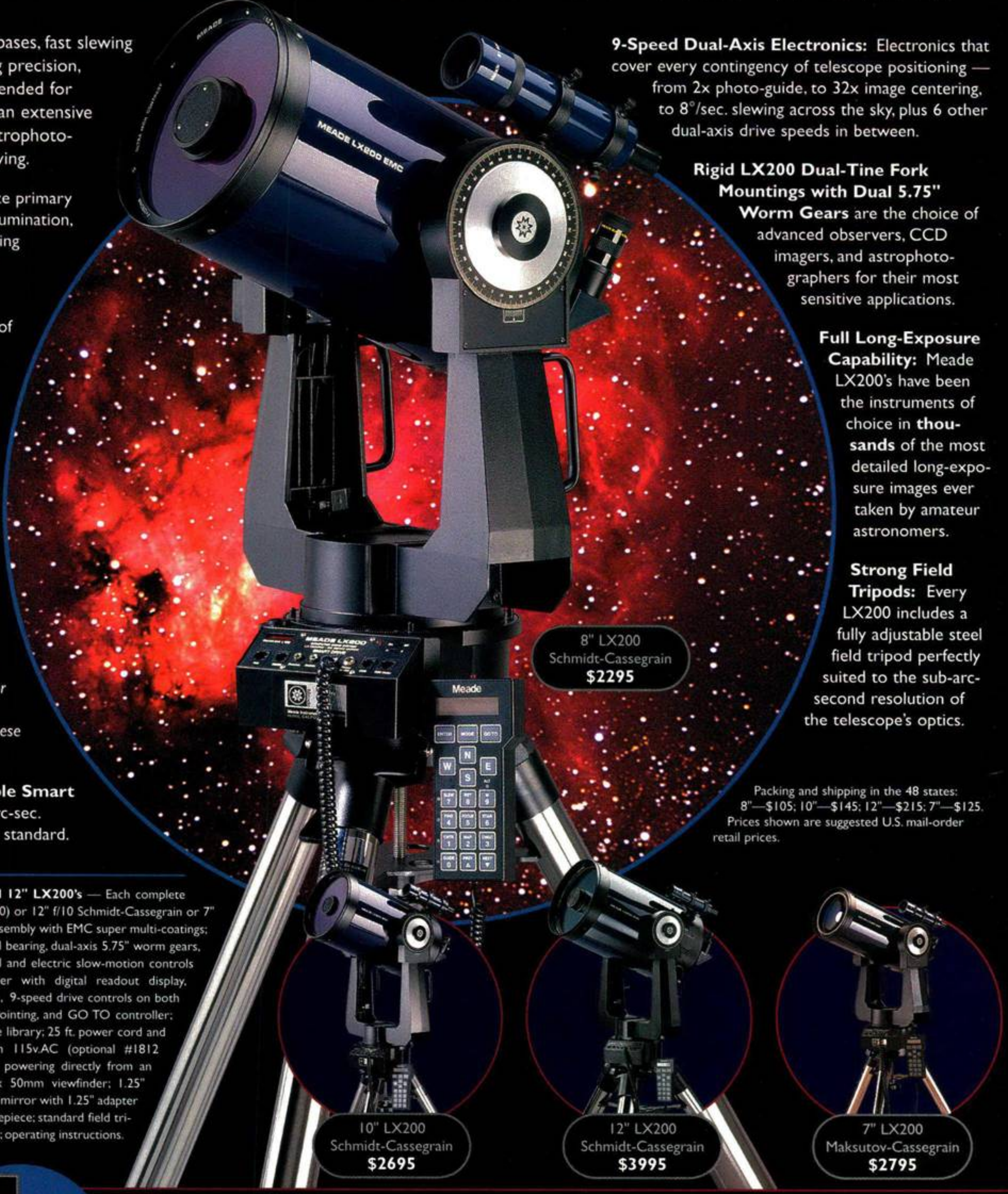
**Permanently-Programmable Smart Drive**™ routinely achieves 5 arc-sec. periodic error, an observatory standard.

**9-Speed Dual-Axis Electronics:** Electronics that cover every contingency of telescope positioning — from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, plus 6 other dual-axis drive speeds in between.

**Rigid LX200 Dual-Tine Fork Mountings with Dual 5.75" Worm Gears** are the choice of advanced observers, CCD imagers, and astrophotographers for their most sensitive applications.

**Full Long-Exposure Capability:** Meade LX200's have been the instruments of choice in **thousands** of the most detailed long-exposure images ever taken by amateur astronomers.

**Strong Field Tripods:** Every LX200 includes a fully adjustable steel field tripod perfectly suited to the sub-arc-second resolution of the telescope's optics.



8" LX200
Schmidt-Cassegrain
**$2295**

10" LX200
Schmidt-Cassegrain
**$2695**

12" LX200
Schmidt-Cassegrain
**$3995**

7" LX200
Maksutov-Cassegrain
**$2795**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125. Prices shown are suggested U.S. mail-order retail prices.

**SPECIFICATIONS: 7", 8", 10", and 12" LX200's** — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug); 8 x 50mm viewfinder; 1.25" diagonal prism (7",8",10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7",8",10") or giant field tripod (12"); operating instructions.

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# Buy a Meade LX200 Schmidt-Cassegrain and receive $600 in Meade premium-grade Super Plössl eyepieces absolutely FREE!

PER PLÖSSL 6.4mm
PER PLÖSSL 9.7mm
PLÖSSL 12.4mm
PLÖSSL 15mm
PER PLÖSSL 20mm
SUPER PLÖSSL 26mm
SUPER PLÖSSL 32mm
SUPER PLÖSSL 40mm

Buy a Meade LX200 Schmidt-Cassegrain between May 15, 2001 and August 15, 2001 and receive a full set of Meade SP 6.4, 9.7, 12.4, 15, 20, 32, and 40mm eyepieces — plus the SP26mm included as standard equipment with every LX200 — free of charge.

Now you can buy a Meade 7", 8", 10", or 12" LX200 Schmidt-Cassegrain telescope — the largest-selling serious telescopes in the world — **and receive a full set of Meade premium-grade Super Plössl eyepieces absolutely free!** Purchased separately, these eyepieces sell for $599.65.

Designed and manufactured to utilize the very latest in optical glasses, Meade Super Plössls deliver wide 52° apparent fields (44° for the SP40mm) with all the resolution, edge-of-field image sharpness, and color correction demanded in the most advanced visual applications. All eyepieces are multi-coated and include soft rubber eyeguards. In combination with the diffraction-limited optics of a Meade LX200, use the Super Plössls at eight magnification levels to observe hairline lunar and planetary detail, split close binary stars, or study tenuous structure in faint nebulae and galaxies.

Each Super Plössl eyepiece is packed in an individual thread-on poly container to keep the eyepiece clean and secure for long-term storage.

## How to Order

**1.** Buy a Meade 7", 8", 10", or 12" LX200 telescope from any authorized Meade dealer in the U.S.A. between May 15, 2001 and August 15, 2001. (See opposite page for specifications.)

**2.** Fax or mail a copy of your dealer's invoice (showing the telescope's serial number) to Meade Instruments/Attn: Customer Service, and request the "Free $600 Eyepiece Offer." *Requests for this special eyepiece offer must be postmarked not later than August 31, 2001, and must include your complete shipping address and phone number.*

**3.** We will ship your free eyepiece package to you within 30 days of our receipt of your request. Meade Instruments will pay for all shipping and insurance charges; safe arrival is guaranteed. This special offer is valid only for new LX200 telescopes ordered and received within the U.S.A.

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EFSTONSCIENCE, Toronto, Ontario, Canada
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KHAN SCOPE CENTRE, Toronto, Ontario, Canada
Orders & Information: 416-783-4140.

July 2001 • Vol. 29, No. 7

# Astronomy®

**COVER PHOTO:** NASA/JPL

## FEATURES

**34** **Quasars Next Door**
Devouring its stellar companion, a black hole or neutron star in our galaxy blasts a high-speed jet into space and looks like a miniature version of its powerful cousin. *Mark A. Garlick*

**40** **Cybertrackers**
Meet someone who discovered six comets in one day. He's part of a growing cadre using the Internet to prove you don't need a Ph.D. to do astronomy. *Mark Sincell*

**46** **Digitizing Astronomy's Glass Plates**
Before the advent of CCDs, almost every facet of the sky was recorded photographically. Now much of that valuable information is being converted into digital data. *Anthony Misch*

COVER

**48** **Mars Returns to Glory**
This summer the Red Planet reaches a size and brightness we haven't seen in 13 years. Here's how to get the most out of viewing Earth's enigmatic neighbor. *Richard Talcott*

**68** **Go to the NexStar on Your List**
*Astronomy* puts Celestron's three new go-to telescopes through their paces. *Glenn F. Chaple, Jr.*

**74** **Happy Trails**
With patience, practice, and attention, you can capture wonderful images of the night sky that record the clockwork motion of the heavens. *Eric DeBolt*

**80** **Celestial Portraits: Ara, Triangulum, and Apus**
This trio of deep southern constellations offers backyard observers pinwheel galaxies, stellar death shrouds, and glittering star clusters. *Tom Polakis*

**68 NexStar's Small Scopes**

*Astronomy*: Jim Forbes

**74 Happy Trails**

Eric DeBolt

**46 Digitizing Astronomy's Glass Plates**

Nina Misch

# DEPARTMENTS

**6 Behind the Scenes**
- Bringing Astronomy to Your Desktop

**14 Talking Back**

**20 AstroNews**
- Supernova Sheds Light on Deep Mystery
- Big Storm Puts Sun in Spotlight
- Resolving to Be Better
- Going Deep in X Rays
- Cosmic Birth of Precious Metals
- Star Birth Rages Like Fire

**56 Sky Show**
- Although Mars will grab everyone's attention this month, don't pass on the chance to see Neptune at its best and Ceres on its 200th anniversary. *Martin Ratcliffe and Alister Ling*

**86 Ask Astro**

**88 Strange Universe**

**90 Star Stuff**

**Products**
- Digi-T
- Meteorite map

**Books**
- *Our Universe: The Magnetism and Thrill of Extragalactic Exploration*
- *Kepler's Philosophy and the New Astronomy*

**98 Looking Ahead**

**106 Advertiser Index**

**107 Hot Shots**
- Fire in the Sky

**112 Ultimate Exposure**

**48 Mars: Get a Glorious View**

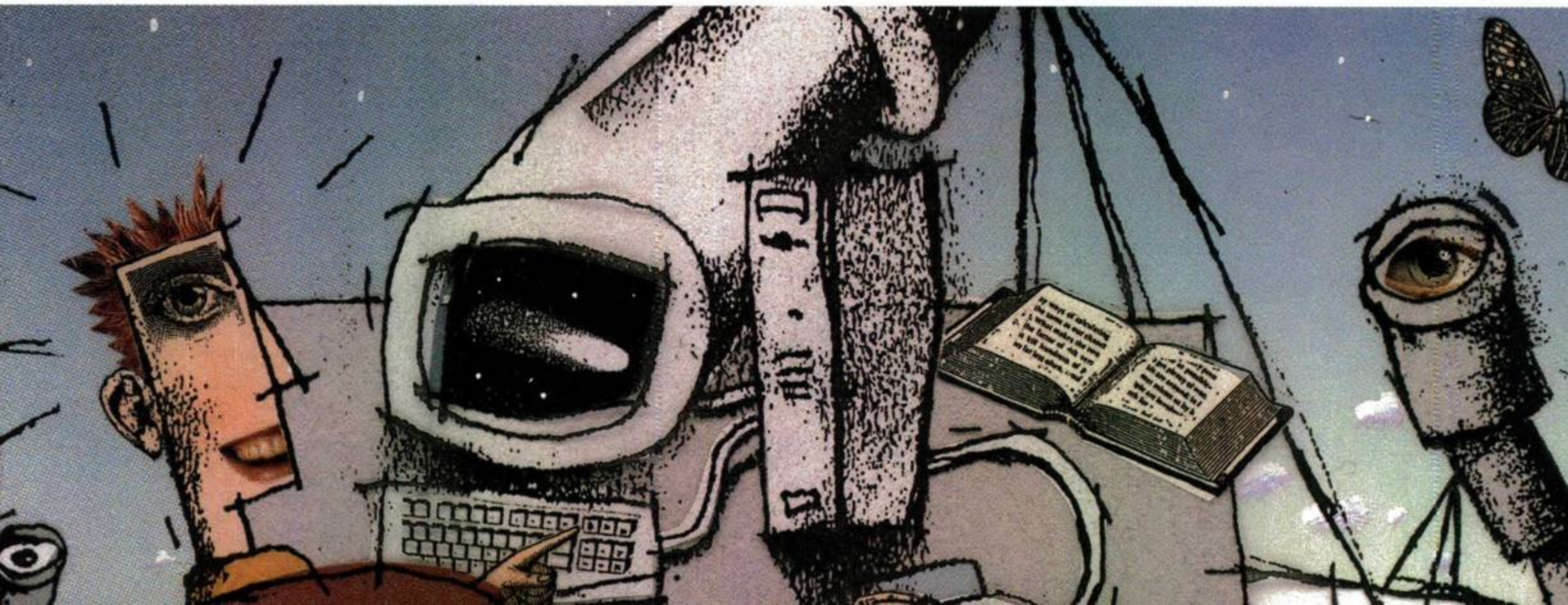
NASA/STScI

**34 Tiny Quasars Litter the Galaxy** Mark A. Garlick

**80 Celestial Portraits**

From *The Glorious Constellations,* © 1991; Harry N. Abrams, Inc.

**40 Bring Astronomy to Your Desktop** Mike Waraksa



**BEHIND THE SCENES**

BY BONNIE BILYEU GORDON

# Bringing Astronomy to Your Desktop

The National Virtual Observatory was probably born before anyone really thought of it. It began with the Internet, which even in infancy promised to offer opportunity for unimagined collaboration and provide science with a fat storage shed of information. Today astronomical data is pouring in from hundreds of telescopes. Teams of researchers around the world have embarked on surveys that will attempt to describe the whole sky at a variety of wavelengths, from radio wave to gamma ray. National Virtual Observatory proponents intend to link all the digital archives into one database available to anyone with a Web connection.

This may sound like a simple task, but it's far from simple. Six years back, a terabyte (a million megabytes) of data was gigantic. Today, the Sloan Digital Sky Survey is expecting to capture 40 terabytes of data as it maps 100 million stars and galaxies. Other surveys claim they will produce 10 megabytes of pure data each day. Just now there is no computer or computer system that can access and combine that information, or even the information in existing archives. But astronomers and computer scientists are working to cure the problem. For some useful insights into how such an infrastructure might entice you into astronomical research on your home computer, see page 40.

Astronomy: William Schomaker

***Astronomy* editors led readers in an aurora hunt in Alaska in March 2001.**

While attending a scientific meeting on virtual astronomy at Caltech last year, I met Elizabeth Griffin, whose job it is to direct a team of astronomers working to transfer information from late 19th- and early 20th-century photographic plates into the digital world. She put me in touch with Anthony Misch, whose story on saving inherited astronomical data is on page 46. Misch, a member of the International Astronomical Union's Working Group for Spectroscopic Data Archives, is a support astronomer at Lick Observatory.

In addition, look to Hot Shots (page 107) for incredible reader-captured photography — including spectacular photos of aurorae. While the solar maximum is supposed to be tapering off, the sun hasn't shown any signs of ordinary behavior this year. Sunspots and flares have been plentiful, making aurorae visible and brilliant as far south as Texas.

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# LX10

MEADE® 8" LX10

## NOW WITH FREE FIELD TRIPOD FOR A LIMITED TIME!

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

MEADE LX10 EMC
MEADE
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S

**Super-Multi-Coated Optical System:** The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as the more expensive Meade 8" LX200.

**Series 4000 Super Plössl 26mm eyepiece:** An $80 eyepiece, the SP26mm complements the exquisite imaging of Meade 8" Schmidt-Cassegrain optics.

**Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power visual applications of the telescope, or for photographic or CCD imaging.

**Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered for 50 hours by four AA-size batteries that fit conveniently into the telescope's control panel.

**Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

**Hand Controller:** Essential for micro-guiding the telescope in R.A. at 2x speed during long-exposure astrophotography. With the optional electric Declination motor *(see below)* added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

**LX10 Field Tripod:** The chromed steel LX10 Field Tripod provides an extremely rigid platform for visual and photographic observations with the telescope. Regularly $195, this tripod is included **free of charge** for a limited time with your purchase of the 8" LX10 telescope.

*This free offer is valid at participating Meade dealers in the U.S.A. and may be cancelled without notice at any time.*

**Limited time offer! $195 LX10 Field Tripod FREE!**

8" LX10
Schmidt-Cassegrain
**$995**

**Electric Declination Motor System** for LX10 . . . . . . . . . . . . . . . . . . . . . . . . . **95.**

**#2014 Magellan I Telescope Computer System** for LX10 with 12,218-object database . . . . . . . . . . . **375.**

**SPECIFICATIONS: 8" Model LX10** — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; LX10 Field Tripod (included only for a limited time, as noted above); complete operating instructions.
**$995.** (+ $65 packing & shipping in the 48 states)

Prices shown are suggested U.S. mail-order prices

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ETX-70AT **MEADE** ETX FREE TRIPOD!

# THE ETX REVOLUTION STARTS AT $299!

Let Meade® high-resolution ETX® optics and standard-equipment Autostar controller take you on an automated guided tour of the Solar System, the Galaxy, and beyond.

**Fork Mount with Dual-Axis Drive System:** Precision worm gear systems permit smooth pushbutton motions of the telescope, as well as sidereal-rate tracking in the altazimuth mode.

**Standard-Equipment #494 Autostar™ Controller:** Includes most of the same features as the more advanced #497 Autostar available for larger ETX models *(facing page)*.

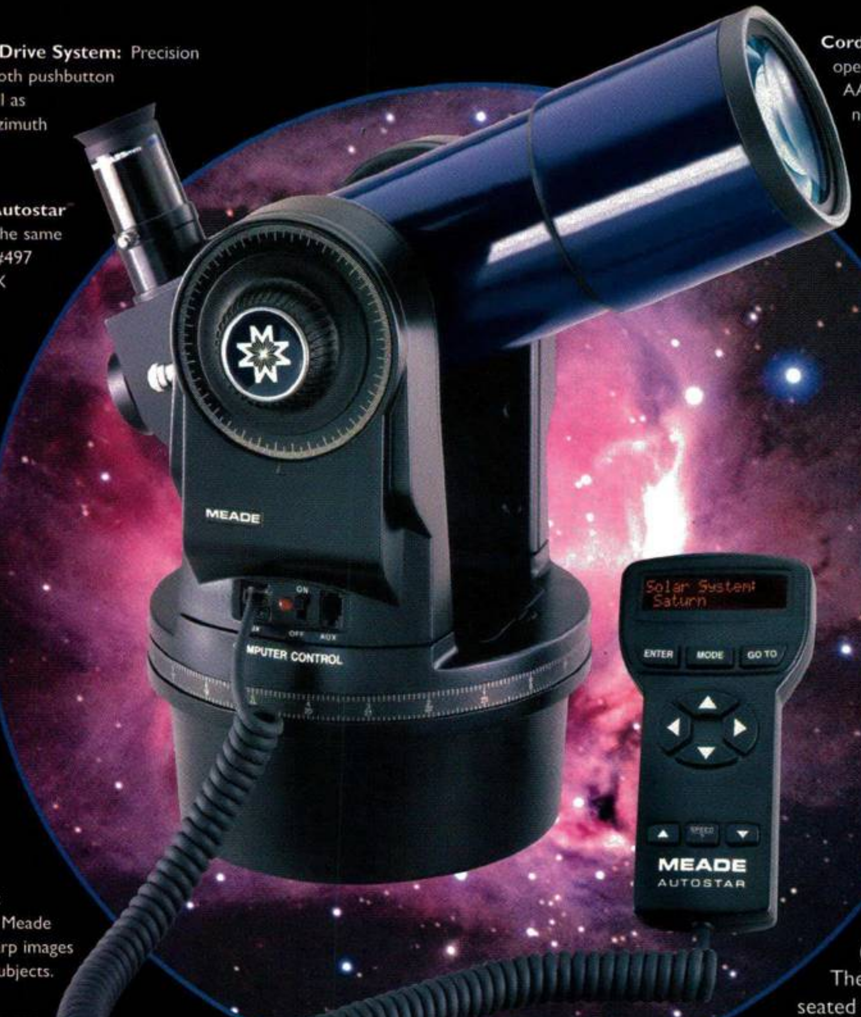
**Automatic dual-axis GO TO function at 4.5°/sec.** to any of more than 1450 database objects, including the complete Messier and Caldwell deep-space object catalogs, the major planets from Mercury to Neptune, 26 asteroids, 15 periodic comets, and more. Or GO TO *any* object of known R.A. and Dec.

**9-speed Dual-Axis Operation:** Pushbutton control of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 4.5°/sec., plus sidereal-rate tracking.

**High-Resolution Achromatic Objective Lenses** of exclusive Meade design; each lens yields razor-sharp images of astronomical and terrestrial subjects.

**Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #933 45° Erecting Prism or for photography with the optional #64ST Photo Adapter.

**Cordless Operation:** The dual-axis drive operates for over 20 hours in the field from six AA-size (user-supplied) batteries which store neatly inside the drive base.



ETX-70AT, complete with #494 Autostar Controller and #882 Field Tripod
**$299**

**Free #882 Field Tripod!**
Regularly $99, now FREE for a limited time!

For a limited time you can purchase a Meade ETX-70AT Astro Telescope and receive a full-length Meade #882 Standard Field Tripod (regularly $99), **absolutely free.** The #882 Tripod is ideal for either seated or standing observations through the telescope.

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**OPTIONAL SYSTEMS FOR MEADE ETX TELESCOPES***

| | | | |
|---|---|---|---|
| #882 Standard Field Tripod (70) | $99.00 | #883 Deluxe Field Tripod (90, 125) | 199.95 |
| #827 8 x 25mm Right-Angle Viewfinder (70) | 49.95 | #825 8 x 25mm Right-Angle Viewfinder (90) | 49.95 |
| #773 Hard Carry Case (70) | 59.95 | #774 Hard Carry Case (90) | 99.95 |
| #933 45° Erecting Prism (70) | 49.95 | #775 Hard Carry Case (125) | 149.95 |
| #64ST Photo Adapter (70) | 19.95 | #932 45° Erecting Prism (90, 125) | 49.95 |
| #497 Autostar Computer Controller (90, 125) | 149.00 | #64 Photo Adapter (90, 125) | 34.95 |
| #880 Equatorial Table Tripod (90) | 29.95 | Electric Focuser #1244 (90) *or* #1247 (125) | 119.95 |
| #881 Equatorial Table Tripod (125) | 59.95 | | |

**see also the Meade accessory ad in this issue.*

**SPECIFICATIONS: ETX-70AT Astro Telescope** — Includes achromatic refractor optical tube assembly (D = 70mm, F = 350mm, f/5) with multi-layer optical coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles, and locks on both axes; electronic control panel; 9-speed (2x sidereal through 4.5°/sec.) dual-axis motor drive system with #494 Autostar computer controller; sidereal-rate tracking; internal compartment accepting six (user-supplied) AA-size batteries; MA9mm (39X) and MA25mm (14X) multi-coated eyepieces; #882 Standard Field Tripod (included only for a limited time, as noted above); operating instructions.
**ETX-70AT — $299** (+$10 packing & shipping in the 48 states)

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ETX-90EC MEADE ETX ETX-125EC

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**Fork Mounts with Dual-Axis Drive Systems:** Each with high-torque DC motors on both telescope axes, permitting electronic operation from the standard-equipment plug-in hand controller.

**Pushbutton Electronic Hand Controller:** Use any of four dual-axis speeds: 8x, 32x, 0.75°/sec., or 5°/sec.

**Maksutov-Cassegrain Optical Systems:** ETX diffraction-limited optics produce images so high in contrast and resolution that ETX telescopes often outperform other telescopes of larger apertures.

**Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter.

**Cordless Operation:** The dual-axis drive system operates for more than 40 hours from eight (user-supplied) AA batteries.

**Save up to $150!**
**ETX-90EC $495**
**Autostar $99 for a limited time!**

ETX-90EC, complete with Electronic Controller
**$495**

ETX-125EC, complete with Electronic Controller
**$895**

**Optional #497 Autostar™ Now Only $99 (regularly $149) For a Limited Time!**

- **Automatic dual-axis GO TO function** at 5°/sec to any of more than 14,000 database objects.
- Select any of Autostar's database objects, or any object of known R.A. and Dec., press ***GO TO*** and the telescope automatically slews to the object.
- **9-Speed Dual-Axis Operation** from 2x sidereal to 5°/sec.

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**SPECIFICATIONS: ETX 90EC and ETX-125EC Astro Telescopes —** Each includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8 or D = 127mm, F = 1900mm, f/15) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles and locks on both axes; electronic control panel; 4-speed (8x, 32x, 0.75°/sec, 5°/sec) dual-axis motor drive system with hand controller; sidereal-rate tracking in equatorial mode with optional table tripod or deluxe field tripod; internal battery compartment accepting eight (user-supplied) AA-size batteries; 8 x 21mm erect-image (ETX-90EC) or 8 x 25mm right-angle (ETX-125EC) viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); instructions. **ETX-90EC — $495** (+ $20 packing & shipping in the 48 states); **ETX-125EC — $895** (+ $30 P & S).

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Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

**Super Plössls** (SP; 4-elements; 1.25"; 52°):

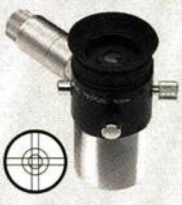
| | | |
|---|---|---|
| **6.4, 9.7, 12.4, 15, 20, 26mm** | each: | **$79.95** (4.54) |
| **32mm** (52°); **40mm** (44°) | each: | **99.95** (5.26) |
| **56mm** (52°; 2") | | **199.95** (7.02) |

## Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

**Ultra Wide Angle** (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

## World's Most Advanced Illuminated Reticle Eyepiece



**Series 4000 Plössl 9mm,** with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

**$149.95** (6.14)

**Series 4000 Plössl 9mm**—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

**$129.95** (5.26)

## Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

**Series 4000 Photo-Visual Color Filters** (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

**#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue**

each **$14.95** (2.73)

| | |
|---|---|
| **Set #1**–4 filters: #12, #23A, #58, #80A | **49.95** (4.54) |
| **Set #2**–4 filters: #11, #25A, #47, #82A | **49.95** (4.54) |
| **Set #3**–4 filters: #8, #21, #38A, #56 | **49.95** (4.54) |

**Series 4000 Moon Filter (#ND96):** Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

## 2x Telenegative Barlow (1.25")

**#122:** Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

**$47.95** (4.54)

## #905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

## 2x Short-Focus Barlow (1.25")

**#126:** Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

## 2x-3x Variable Barlow (1.25")

**#127:** Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

**$59.95** (4.54)

## 2" Diagonal Mirror

**#929:** Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

**#929** or **#930,** each: **$99.95** (6.85)

## 45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

**$42.95** (3.86)

## Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

**#1206 Electric Focuser:** Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

**#1205 Electric Focuser:** For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

**$169.95** (7.88)

## #777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

**$79.95** (6.85)

## Series 4000™ 2x Apochromatic Barlow Lens

**#140:** The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

**$79.95** (5.26)

## Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

**Super Wide Angle** (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

## Series 3000™ Plössls 50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

**Series 3000 Plössls** (4-elements; 1.25"; 50°)

**5, 6.7, 9.5, 16, 25mm** each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

#911B
#910B
#908B
#911N
#910N
#908N

**Series 4000 Nebular Filters**—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

| | |
|---|---|
| **#908B**–Threads into 1.25" eyepieces, 26mm dia. | **79.95** (4.54) |
| **#910B**–Threads into 2" eyepieces, 44mm dia. | **119.95** (5.26) |
| **#911B**–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. | **99.95** (5.26) |
| **#908N**–Threads into 1.25" eyepieces, 26mm dia. | **89.95** (4.54) |
| **#910N**–Threads into 2" eyepieces, 44mm dia. | **129.95** (5.26) |
| **#911N**–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. | **119.95** (5.26) |

#911X
#910X
#908X

**Series 4000 Oxygen-Ⅲ Filters** Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-Ⅲ lines to tremendously enhance observable nebular structural detail in all telescopes.

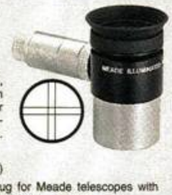
| | |
|---|---|
| **#908X**–Threads into 1.25" eyepieces, 26mm dia. | **99.95** (4.54) |
| **#910X**–Threads into 2" eyepieces, 44mm dia. | **159.95** (5.26) |
| **#911X**–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. | **149.95** (5.26) |

## Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

## MA12mm Illuminated Reticle Eyepiece

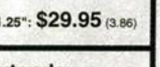


Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

**$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

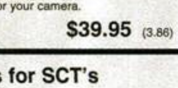
## Camera Adapters



Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

## Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

**$39.95** (3.86)

## Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

**$39.95** (3.86)

## T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

**$26.95** (3.66)

## CCD-Photo-Visual Flip-Mirror Systems

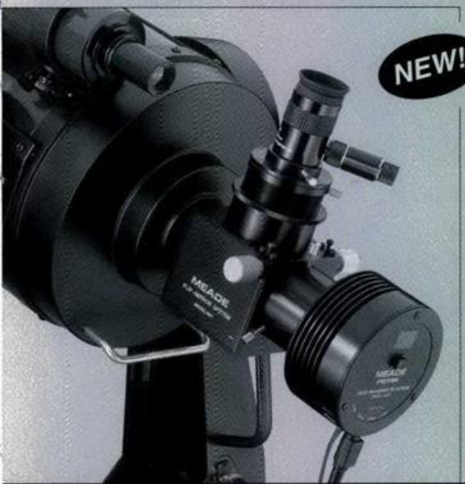
An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

*"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope."* — Jack Newton

**#644 Flip-Mirror System:** Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

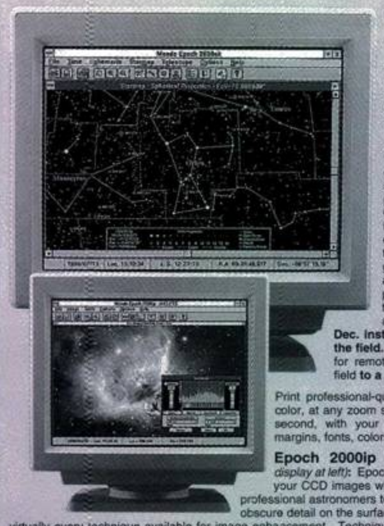
**#647 Flip-Mirror System:** Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

**#157 1.25" Adapter:** Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)



#644

#647



## Epoch 2000® Sky Software

### The most powerful astronomical software ever made available can now be yours for only $149!

**Epoch 2000sk** *(upper display at left)*: Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

**Epoch 2000ip Image Processing Software** *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

**EPOCH 2000sk Sky Software:** 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 .......... **$149**

**EPOCH 2000sk-CD Sky Software:** 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM .......... **179**

**LX200 Interface Cable:** for Meade LX200 operation by Epoch 2000sk .......... **25**

**EPOCH 2000ip Image Processing Software:** Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 .......... **$199**

f/3.3 CCD FOCAL REDUCER

## Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

NEW!

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

## Plössl 25mm Illuminated Reticle CCD Framing Ocular

NEW!
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CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

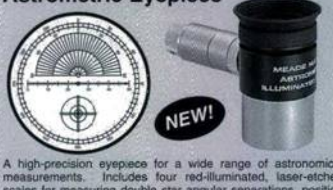
## #825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

## #64 T-Adapter for ETX®

Threads to the photo port of all ETX-90 and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

## MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

## Series 4000™ 8mm – 24mm Zoom Eyepiece

NEW!

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

## ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, plus optional eyepieces, erecting prism, table tripod, hand controller, *etc.* Includes two steel latches with key.

**#774** Case for ETX-90 models: **99.95** (8.58)

**#775** for ETX-125EC: **149.95** (13.38)

## #932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90 or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics. **$49.95** (3.86)

## Advanced Field Tripod for ETX-125

**#887:** Yields *rock-solid* stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport. **$349.95** (14.00)

## Tripod Adapter for ETX-125

Included with the #887 Tripod *(above)*, the #889 Adapter is available separately and permits attachment of ETX-125 directly to any Meade LX10, LX50, or LX200 Schmidt-Cassegrain Field Tripod for altazimuth observing or to any Meade Schmidt-Cassegrain Tripod-with-Equatorial Wedge or Superwedge for equatorial applications. **#889 Adapter:** **$69.95** (7.70)

## ETX® Deluxe Field Tripod

**#883:** Custom-designed by Meade specifically for ETX-90 and ETX-125 Astro Telescopes. Tripod height adjusts from 34" to 54", for seated or standing observations. Micrometric controls in azimuth and elevation permit precise polar alignment of the ETX fork mount. Tripod head tilts and locks to 90° for terrestrial applications. Telescope attaches to tripod in seconds with 2 thumbscrews. All-aluminum construction. **$199.95** (10.00)

## ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories. **$36.95** (5.26)

NEW!

## Electric Focusers for ETX®

ELECTRONIC CONTROLLER
MEADE

Meade-engineered for smooth, rapid focusing with any ETX model. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus ETX/EC models through the telescope's hand controller.

**#1244 Electric Focuser** for all ETX-90 models: **$119.95** (6.85)

**#1247 Electric Focuser** for ETX-125 models: **$119.95** (6.85)

# HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

**ASTRONOMICS, Norman, OK.**
**Orders: 800-422-7876; Info.: 405-364-0858.**

**FOCUS CAMERA, Brooklyn, NY.**
**Orders: 800-221-0828; Info.: 718-436-6262.**

**LUMICON, Livermore, CA.**
**Orders: 800-767-9576; Info.: 925-447-9570.**

**OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.**
**Orders & Information: 800-483-6287.**

**POCONO MOUNTAIN OPTICS, Moscow, PA.**
**Orders: 800-569-4323; Info.: 570-842-1500.**

**RIVERS CAMERA, Dover, NH.**
**Orders: 800-245-7963; Info.: 603-742-4888.**

**SHUTAN CAMERA & VIDEO, Chicago, IL.**
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TALKING BACK
FROM OUR READERS

# Animal Astronauts

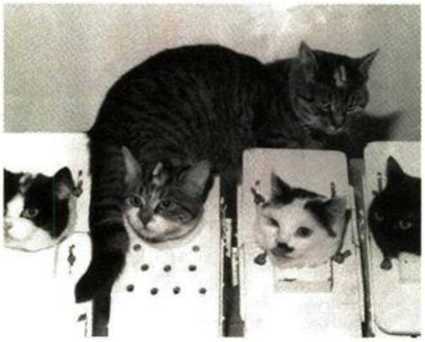
Thanks for spotlighting the sorry early years of space animal experiments (see "Reluctant Astronauts," April 2001). Unfortunately, such mistakes continued during the intervening decades, including such fiascoes as Bion 10 and the Neurolab space shuttle mission, which carried animal experiments into space. Unless plans change, the International Space Station Alpha will serve as the venue for the most extensive animal experimentation yet: Thousands of rats, mice, fish, snails, sea urchins, insects and other animals will be pointlessly abused for up to three months at a time.

So, despite of the two main reasons advanced for the animal experiments — learning how humans will cope with long space voyages, and gaining vital Earth-application spinoffs for human health — only the human data is truly useful. NASA literature repeatedly stipulates "living creatures deserve respect." Their plans belie that claim. — *Neal D. Barnard, M.D., President, Physicians Committee for Responsible Medicine, Washington, D.C.*

In June 1998, Oleg Gazenko — by no means an animal rights activist — who headed the early Soviet animals-in-space program, expressed his deep regret about Sputnik 2 and Laika during a Moscow news conference. "The more time passes, the more sorry I feel. We shouldn't have done it," said Gazenko. "We did not learn enough to justify the death of a dog."

Let's hope the decision makers at NASA and their counterparts at other space agencies ponder that four-decades-late hindsight, and avoid adding to the shameful history of animal astronauts. — *Murry J. Cohen, M.D., Annandale, Virginia*

I object to your glorifying the use of animals in space experiments and advocating writing essays to nominate pets for future NASA space missions. Pet lovers wouldn't do that. — *Name withheld by request, Salem, Oregon*



**French cats were trained for simulated spacesuit confinement.** Hulton-Deutsch Collection/CORBIS

*The article was meant to inform, not glorify. The public needs to know what happened and what needs changing.* Astronomy *staff members were sickened by the horrible treatment suffered by innocent animals.*

You got caught in one of the most common misquotes ever in the "Reluctant Astronauts" article (April 2001). The famous Shakespearean quip from Hamlet actually reads, "Alas, poor Yorick! I knew him, Horatio … " *Charles Gallo, Bayside, New York*

**Humorous Universe**

Thanks for running Bob Berman's columns. His ability to combine interesting information with wry humor has made *Strange Universe* my favorite part of the magazine — although from the letters you receive, some readers seem not to understand when Berman is joking. I hope that everyone at least got the point of his delightful April Fools column. — *Charles Johnson, Petaluma, California*

**Details, Details**

In the April 2001 article "Get The Hole Story," the diagram on page 53 portrays a comet that has already passed perihelion while orbiting a black hole. The error is that the comet tail is pointed away from the black hole, into space. — *Kevin Nalty, Kalispell, Montana*

*You are correct. The tail of the farthest left comet in the diagram should point the opposite way. However, because comet tails are a function of a star's radiation, and, in theory, black holes are famous for just the opposite effect, a comet passing near a black hole wouldn't display a tail at all.*

*While we hoped the diagram would illustrate the point, it instead confused the issue. In other words, we should have hidden our tails on this one.* — Astronomy *editors*

On page 51 of the April 2001 issue, the "short time" over which virtual particles annihilate each other is $10^{-23}$ seconds, not $10^{23}$ seconds — which is more than 100,000 times the present lifetime of the universe. Our thanks to the many readers who caught this. — *Astronomy* editors

**An Author's Comment**

In "Hole Story," on page 52, "Yeah, but, a black hole is a place that is outside the regular universe. It is a hole or gap in the fabric of the universe," should have been italicized. It originally came from a third party, and I refuted it in the following sentences.

Incidentally, Tom O'Toole, a space shuttle engineer from California, calculated that the tidal force across a comet nucleus would be on the order of 65,000 Gs at closest approach to the hole. This assures that the comet nucleus would be pulled apart.

O'Toole also calculated that the technology exists to send a high-tech probe to within 300 km of a black hole while remaining functional. We probably won't need to use that technology in the near future, but it is interesting to know that we can do it. — *Neil F. Comins, Professor, Dept. Physics and Astronomy, University of Maine*

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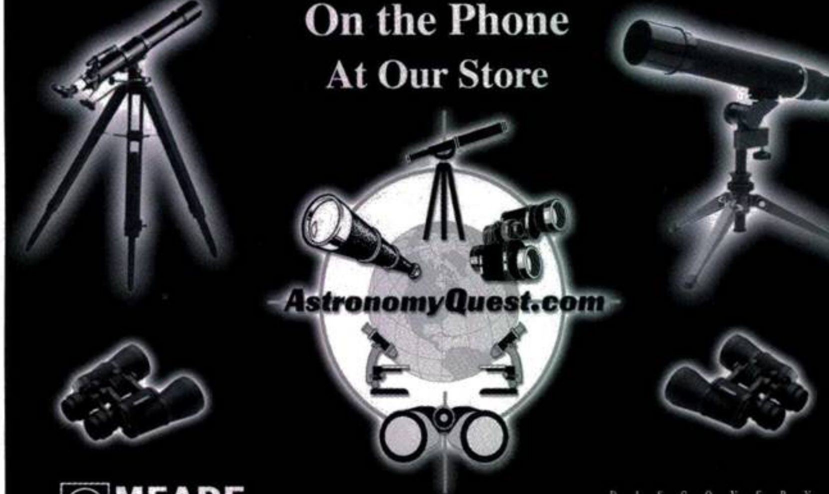

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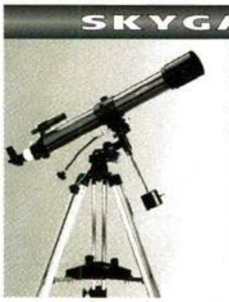

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## Telescope Differences

In April's *Ask Astro* section, Gary Haley asked about the differences between Maksutov-Cassegrains and Schmidt-Cassegrains.

Contrary to Mr. Shibley's response that the main difference is in the way light is reflected back to the eyepiece, I believe the corrector designs constitute the greatest difference.

The corrector on a Schmidt telescope is called a "plate." The corrector on a Maksutov telescope is a deep meniscus referred to as a "shell." While the most widely-recognized Maksutov telescopes incorporate a corrector lens with a secondary mirrored "spot" which provides an independent (detached) element that gives the lens designer an edge to improve the instrument's performance, many Maksutov designs also feature independent secondary mirrors. The comment that Maks "don't have a secondary mirror, but rather a patch of reflective aluminized coating on the underside of its glass corrector plate" is incorrect.

Mr. Shibley continues, "Maks also yield higher power for a given set of eyepieces when compared to an SCT of the same aperture." Close, but no cigar. True, most Maks have longer focal lengths than comparable SCTs. But focal ratio — not instrument or aperture — determines the difference in eyepiece magnification.

The SCTs have thinner correctors and cool down faster than the Maksutov telescopes. However, well-corrected Maksutovs tend toward less field curvature and better off-axis image quality. Because Maks have a longer focal ratio, the secondary mirror is generally smaller, resulting in higher-contrast images of the moon and planets. — *William J. Cook, Editor,* Amateur Telescope Making Journal, *Seattle, Washington* ■

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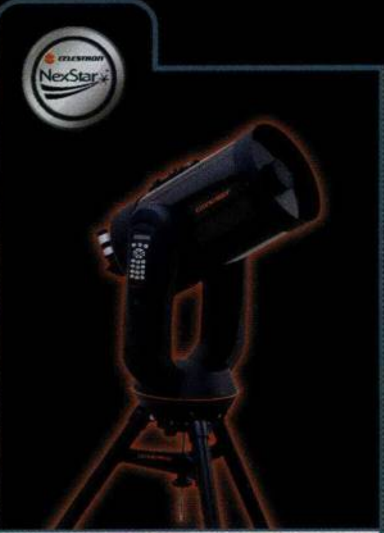

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COSMOLOGY

# Supernova Sheds Light on Deep Mystery

▶ Yet again, astronomers have strengthened the case for truth being stranger than fiction. According to the latest news from the Hubble Space Telescope, the universe is likely dominated by a mysterious dark force that's hurling galaxies apart at an ever-increasing rate. What's more, astronomers now believe that the reign of this dark master began only about 4 billion to 8 billion years ago.

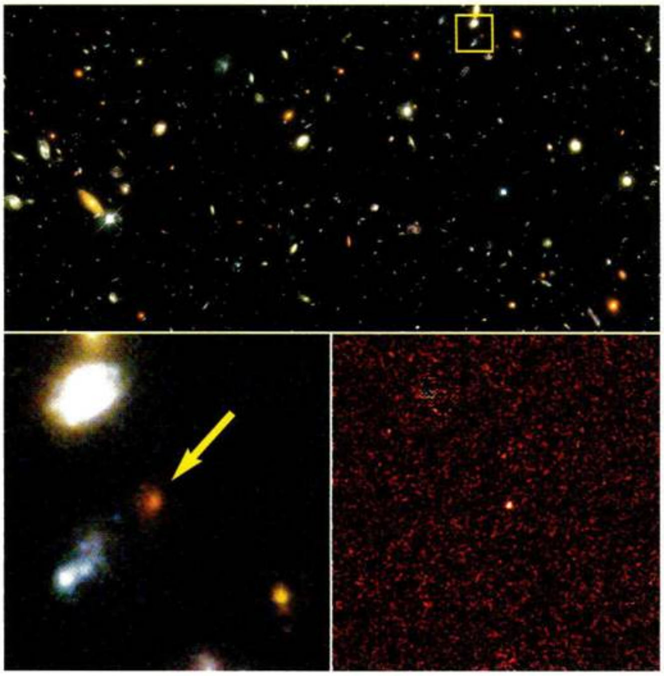
Adam Riess of the Space Telescope Science Institute (STScI) and Peter Nugent of Lawrence Berkeley National Laboratory (LBNL) analyzed Hubble observations of the most distant known supernova. Designated SN 1997ff, the supernova provides the best proof yet for an accelerating universe. With a redshift of 1.7, meaning the expansion of the universe has shifted its light toward longer wavelengths by 170 percent, SN 1997ff is some 11.3 billion years old. Its great age and distance open a new window on the history of the universe and its expansion.

"The supernova appears to be one of a special class of explosions that allows astronomers to understand how the expansion of the universe has changed over time, much as the way a parent follows a child's growth spurts by marking a doorway," says Riess. "SN 1997ff shows the universe is behaving like a driver who slows down approaching a red stoplight and then hits the accelerator when the light turns green."

Thanks to Edwin Hubble's epic 1929 discovery, astronomers have long known that the universe is expanding. But it wasn't until 1997 that they found good reason to believe the expansion is actually speeding up. It was then that members of the Supernova Cosmology Project and the rival High-Z Supernova Search Team found that Type Ia supernovae — white dwarfs that detonate when they pull enough material from a companion star to exceed a critical mass of 1.4 solar masses — with redshifts greater than 0.5 are dimmer than expected. That places them farther away than their redshifts would indicate if the universe were simply coasting under the mutual gravity of its constituent parts. Riess and Nugent believe that the era of acceleration likely began when the universe was roughly half its present age.

Naysayers propose that distant Type Ia supernovae may be dim for reasons other than an accelerating universe dominated by dark energy. But the brightness of SN 1997ff bolsters the acceleration model while ruling out many of the popular alternative theories.

"SN 1997ff argues against the notion that observations of distant Type Ia supernovae may be systematically distorted by intervening gray dust or the chemical evolution of the universe," offers Nugent.



Adam Riess (STScI) and NASA

**A supernova in the Hubble Deep Field suggests an accelerating universe. SN 1997ff, found in a 1997 HDF image (top), occurred in a faint galaxy (arrow in close-up, above left). The supernova popped out when the 1995 HDF was subtracted (above right).**

STScI astronomer Ron Gilliland and Carnegie Institution colleague Mark Phillips discovered SN 1997ff in a tiny region of the famous Hubble Deep Field. Rodger Thompson of the University of Arizona targeted it again with Hubble's Near Infrared Camera and Multi-Object Spectrometer 25 days later. And STScI's Mark Dickinson observed it yet again six months after that. This unique combination of archived optical and infrared data allowed Riess and Nugent to determine — four years later — that SN 1997ff holds the current Type Ia distance record and possibly the answer to one of the greatest mysteries of the universe.

Still, astronomers caution that textbooks shouldn't be revised overnight. "This is an extraordinary result, which requires extraordinary scrutiny," warns University of Chicago astrophysicist Michael Turner. In fact, recent studies show that as many as 36 percent of Type Ia supernovae may be peculiar — either brighter or fainter than normal. While Riess and Nugent remain confident that SN 1997ff isn't peculiar, further space-based studies of distant supernovae — using observatories such as the planned LBNL SuperNova/Acceleration Probe (SNAP) — should eliminate any doubt as to when and how the universe began accelerating. — WILLIAM SCHOMAKER

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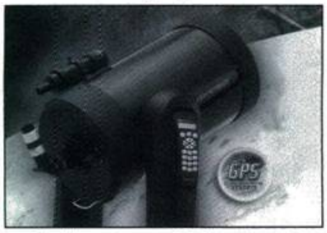

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SOLAR PHYSICS

# Big Storm Puts Sun in Spotlight

You won't often find people staring at the sun on a typical spring day, but, then again, there wasn't much typical about this morning in late March. Using filters ordinarily reserved for solar eclipse viewing, the *Astronomy* staff took turns looking at the sun and marveling at the dark blemish on its face — the largest sunspot group of the past decade.

The group spanned a staggering 87,000 miles (140,000 km), some 11 times the diameter of Earth, and easily ranked as the largest sunspot group of the current solar cycle. For such an impressive region, solar scientists saddled it with a mundane designation — active region 9393. And "active" didn't begin to describe what this region had in store.

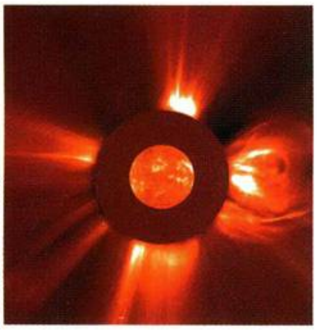
The twisted, snaking magnetic fields associated with active region 9393 repeatedly snapped during late March and early April, creating several huge solar flares. The biggest flare erupted at 4:51 P.M. EDT on April 2 and released more energy than a billion megatons of TNT.

"This explosion was estimated as an X-20 flare, and was as strong as the record X-20 flare on August 16, 1989," said Paal Brekke, the European Space Agency's Deputy Project Scientist for the Solar and Heliospheric Observatory (SOHO). The flare was later reclassified as at least an X-20 flare — the highest designation possible — and appears to be the largest flare ever recorded during the 25 years of regular x-ray observations. It was certainly more powerful than the March 6, 1989, X-15 flare that caused major power failures in Canada.

The big explosion also hurled a massive cloud of charged particles into space at the whopping speed of 4.5 million miles per hour (7.2 million km/hr). Luckily, this coronal mass ejection wasn't aimed directly at Earth — the active region was near the sun's northwestern limb at the time — so the effects on our planet were pretty subdued.

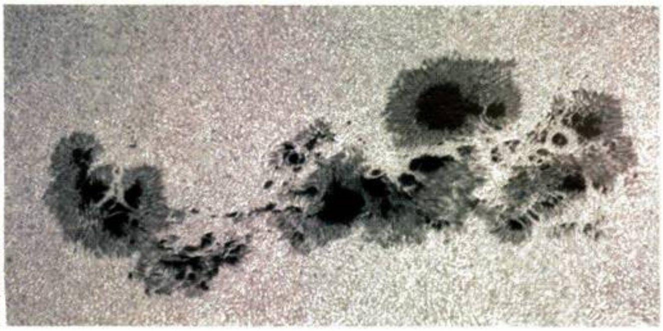
However, several smaller flares and coronal mass ejections occurred in the week preceding the largest one. One produced a powerful geomagnetic storm that raged for more than 24 hours and dazzled skygazers, who witnessed brilliant displays of the aurora borealis as far south as Mexico. (See Hot Shots on page 107 for some outstanding aurora photos.)

— RICHARD TALCOTT



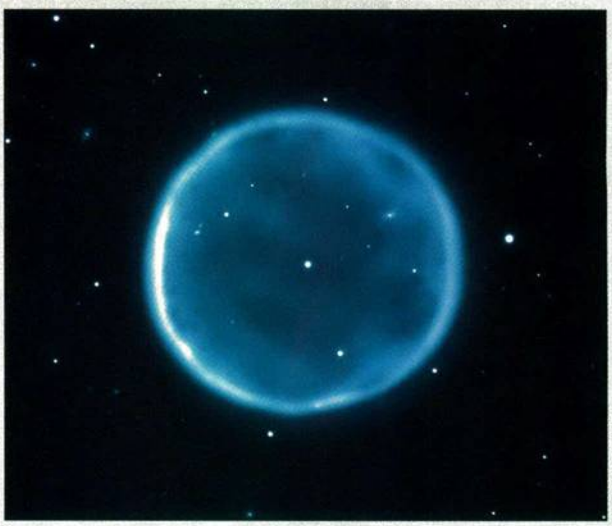
SOHO (ESA and NASA)

**The largest sunspot group in a decade (below) led to the biggest solar flare on record and a huge coronal mass ejection (left).**



NSO/AURA/NSF

PLANETARY NEBULAE



WIYN/NOAO/NSF

**A QUINTESSENTIAL PLANETARY NEBULA, Abell 39 is the expanding shell of a sunlike star's outer layers being heated from inside by a glowing hot, white dwarf core. Its unusual spherical geometry makes it a perfect specimen for astronomers hoping to understand exactly how Abell 39 and other planetary nebulae are able to chemically enrich the surrounding interstellar medium as they expand. Previous studies of planetary nebulae have been hampered by uncertain geometry. This image was taken through a blue-green filter with the WIYN Observatory's 3.5-meter telescope atop Kitt Peak in Arizona. Located some 7,000 light-years from Earth in the constellation Hercules, Abell 39 has a diameter of 5 light-years and a thickness of about 0.3 light-year. It is not yet known why the remnant white dwarf lies slightly off-center, displaced to the right by less than 0.1 light-year.**

INSTRUMENTATION

# Resolving to Be Better

This spring was a great one for astronomers, who ventured two steps closer to realizing their dream of detecting Earthlike planets around nearby stars. Both the Keck Interferometer and the Very Large Telescope Interferometer (VLTI) cleared similar technological hurdles, underscoring

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the potential for optical interferometry to deliver on its long-held promise.

Interferometry — the controlled interference of light waves from several telescopes in order to achieve the resolving power of a single giant telescope, with an aperture equal to the separation of the components — may help to answer such tough questions as, How did we get here? and, Are we alone? The technique will be key to capturing images and measuring positions of small celestial objects such as nearby, low-mass planets. But technical challenges and exorbitant construction costs have hindered the realization of optical interferometer technology, even though radio astronomers have enjoyed interferometry's proceeds for decades.

On March 12, 2001, the W. M. Keck Observatory's twin 10-meter telescopes, located on Mauna Kea on the big island of Hawaii, successfully joined to yield a resolution equivalent to an 85-meter telescope, making it the most powerful optical telescope system in the world. "Combining the light from the two largest telescopes on Earth is a fabulous technical advancement for science," says Anne Kinney, director of NASA's Astronomical Search for Origins program, which includes the Keck Interferometer project.

After linking the twin telescopes with a 275-foot underground optical delay system, capable of adjusting the combined light path within one millionth of one inch, Keck astronomers were treated to a clear view of the 6th-magnitude star HD 61294 in Lynx. Although still in the testing phase, the interferometer should begin scientific operations this autumn.

Five nights later at the European Southern Observatory's Paranal facility in the Chilean Andes, two 0.4-meter VLTI auxiliary telescopes, designed to test the VLTI optical delay line, gathered light from the 2nd-magnitude star Alphard (Alpha Hydrae). Confirming the great power of interferometry, technicians were able to measure the diameter of the star. At a mere 0.00929 arcsecond (plus or minus 0.00017 arcsecond), the task is equivalent to discerning the separation between a pair of car headlights at 22,000 miles (35,000 km). Upon completion of the VLTI system in late 2001, two of the VLT's four 8.2-meter telescopes will combine forces with several moveable 1.8-meter auxiliary telescopes to achieve an unprecedented optical resolution of 0.0005 arcsecond — sufficient to spy 2-meter objects as far away as the moon.

"This is a major step in the creation of a whole new class of telescopes that will have an enormous impact on future knowledge," says Paul Swanson, Keck Interferometer project manager at NASA's Jet Propulsion Laboratory. — W. S.

**The Very Large Telescope in Chile (top) and the Keck telescopes in Hawaii (above) have both cleared hurdles in becoming interferometers.** Top: ESO; above: JPL/Caltech/NASA

*X-RAY ASTRONOMY*

# Going Deep in X Rays

▶ For nearly 40 years, astronomers have wondered what causes the diffuse glow of high-energy x rays that emanate from the distant universe. This x-ray background has a similar appearance to the much more famous microwave background, the cooling relic radiation that traces back to the Big Bang. But there's no way hot x rays could be left from that ancient time — the source had to be far different.

The latest observations from the Chandra X-ray Observatory and large ground-based telescopes have finally solved the mystery. The culprits: supermassive black holes accreting gas and dust in the centers of distant galaxies. "The Chandra data show us that giant black holes were much more active in the past than at present," says Riccardo Giacconi of Johns Hopkins University, the person who discovered the x-ray background with a pioneering rocket experiment in 1962.

The problem for astronomers had always been that x-ray telescopes just didn't have the fine resolution achieved by optical and radio telescopes. Most astronomers thought the x-ray background came from individual objects spread across the sky, but without the ability to resolve objects that lie close to one another, the faint x rays just blurred together.

That's all changed since the 1999 launch of Chandra. The spaceborne

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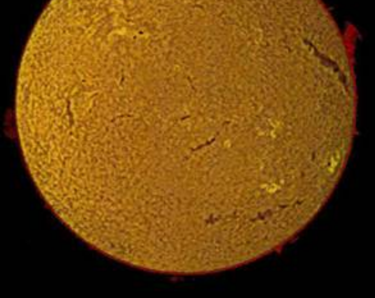

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observatory has the ability to resolve objects within just 1 arcsecond of each other, about as good as ground-based optical telescopes typically achieve.

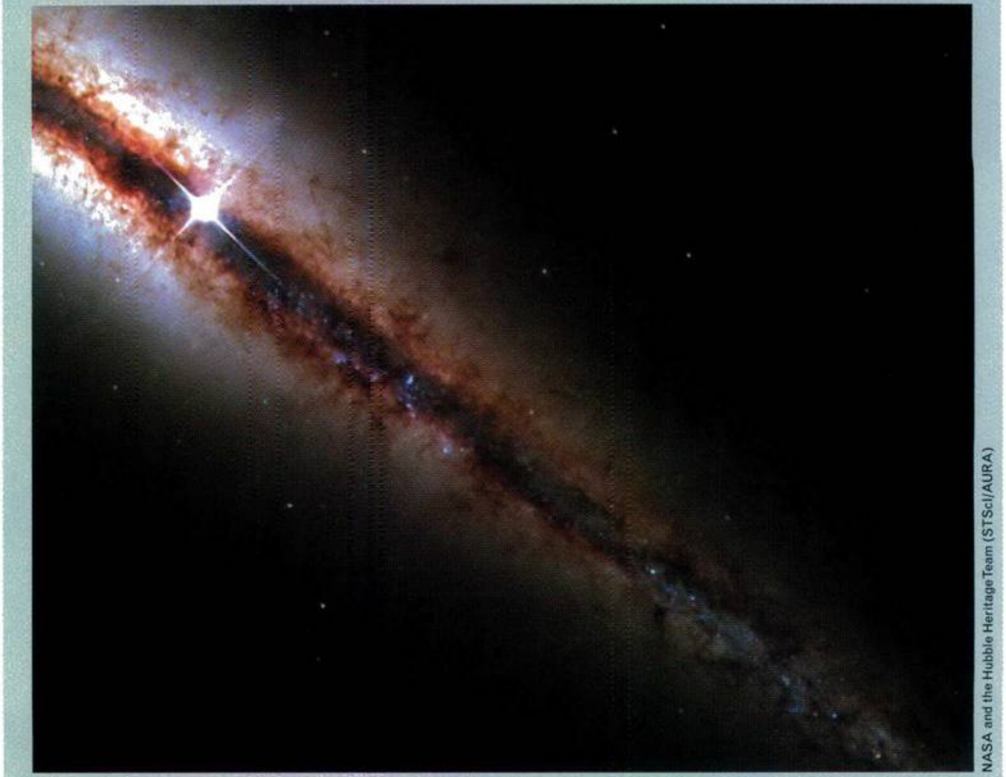
The recent observations mimicked those of the Hubble Space Telescope's famed Deep Field. Chandra astronomers pointed their telescope at two patches of sky well away from the obscuring band of the Milky Way —one in the northern constellation Ursa Major and the other in the southern constellation Fornax — for a total of nearly one million seconds (11.5 days).

Chandra detected more than 300 x-ray sources in the Deep Field South. The key link between the individual objects and the x-ray background came from adding the contributions of all the Chandra sources and seeing that the sum matched both the intensity and spectral characteristics of the observed background.

A team of ground-based optical astronomers then used the European Southern Observatory's Very Large Telescope in Chile to follow up on the individual sources. The team identified and took spectra of more than 100 sources and confirmed that most were active galactic nuclei or quasars. Most astronomers are convinced that these objects derive their enormous power from supermassive black holes devouring nearby gas and dust.

The astronomers also discovered the first "Type II quasar" in the very distant universe, at a distance of some 12 billion light-years. These objects, heavily obscured by dust and thus hard to see, are believed to account for 90 percent of the quasars in the distant universe. "The thinking is that these may be quasars in the early stages of their evolution," says team member Colin Norman of Johns Hopkins. "As the quasar matures, the extremely powerful radiation it emits disperses the shroud of gas and dust." — R. T.

### HUBBLE SPACE TELESCOPES



NASA and the Hubble Heritage Team (STScI/AURA)

**THE PERFECTLY EDGE-ON SPIRAL GALAXY NGC 4013 lies 55 million light-years from Earth in Ursa Major. Glowing at 11th magnitude, it can be viewed easily by amateur astronomers, but no backyard telescope can show the exquisite detail seen in this Hubble Space Telescope image. Taken by J. Christopher Howk of Johns Hopkins University and Blair Savage of the University of Wisconsin, the image shows a little more than half the galaxy, which is larger than Hubble's field of view. Innumerable clouds of interstellar dust absorb light from more distant stars, creating the dark band that splits the galaxy. Such clouds are the birthplaces of new stars. Once the dust disperses, the young stars become visible as clusters of blue stars. Several of these clusters appear along the galaxy's equator, but the brilliant star near the upper left corner is a foreground star in the Milky Way.**

NASA/JHU/AUI/R. Giacconi, et al.

**The Chandra Deep Field South has resolved the long-mysterious x-ray background into numerous quasars and active galaxies.**

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*NEUTRON STAR MERGERS*

## Cosmic Birth of Precious Metals

Thanks to the latest supercomputer research, precious metals like gold and platinum — special in the hearts of wives and husbands — just secured an equally special station in the cosmos. Scientists have long suspected that Earth's more plentiful elements, such as oxygen, carbon, and nitrogen, were forged in the cores of massive stars. Still, the origin of heavier and rarer elements remained a stubborn mystery.

According to current thought, supernovae can't populate the universe with enough gold and platinum to justify their Earthly abundances. But a team of British astronomers, led by the University of Leicester's Stephan Rosswog, and their Swiss colleagues from the University of Basel think they've got the answer — colliding neutron stars.

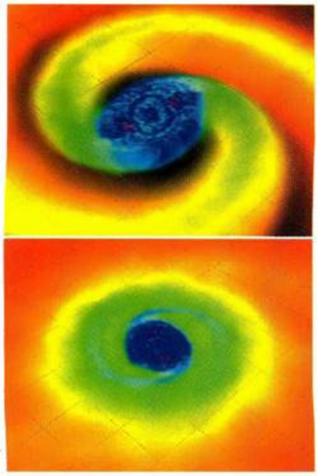
With a million times the mass of Earth packed into a sphere no larger than a city, neutron stars are the remnant cores of massive stars gone supernova. Mergers between binary neutron stars, though rare, apparently spark some gamma-ray bursts — the most energetic events in the universe. Now, it appears that neutron star mergers also litter the universe with heavy elements.

Rosswog's team simulated a binary neutron star merger using the new Origin 3800 supercomputer at the UK Astrophysical Fluids Facility in Leicester. The model begins with two neutron stars, each with 1.4 times the mass of the sun, separated by about six miles. At this distance, the fuzzy realms of quantum mechanics and general relativity take over. The stars circle each other at more than 200 million miles per hour, merging to form a black hole within a few milliseconds. (To see movies of the merger, visit www.ukaff.ac.uk/movies/nsmerger/.)

The team's calculations show that as the neutron stars merge, material is heated to 100 billion degrees and ejected from the system. As the scattered remnant ash cools, iron nuclei continuously capture neutrons, forming heavier elements like gold and uranium. This material then peppers the surrounding interstellar medium from which subsequent generations of stars will form, perhaps millions of years later.

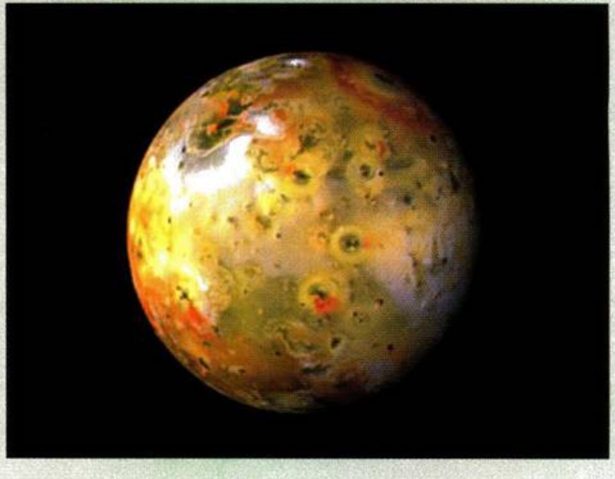
The researchers reveal that the relative quantities of heavy elements formed in their model agree with those found in the solar system, suggesting that our sun and planets likely formed from such material. — W. S.

**Supercomputer simulations show that during a neutron star merger, temperatures spike to 100 billion degrees and the stage is set to form heavy elements.**



Stephan Rosswog (Univ. of Leicester)

**GALILEO MISSION**



NASA/JPL

**A PLUME BLASTING 250 MILES above the surface of Io has even surprised planetary scientists accustomed to the jovian moon's extraordinary behavior. The new plume originates from a volcanic feature named Tvashtar Catena, located near Io's north pole. Although it's about the same size as the long-lived plume erupting from Io's Pele volcano, scientists were astounded to find such a large plume so near the pole. All previous plumes erupted over equatorial regions, and none had approached the size of Pele. (The plume can't be seen in this Galileo image, but fresh surface deposits appear as a bright red ring at upper right.) Galileo will pass just 225 miles (360 km) above Tvashtar this August, but the plume's tenuous nature will pose little threat to the spacecraft.**

*STELLAR EVOLUTION*

## Star Birth Rages Like Fire

In the public's mind, stars represent the universe's ultimate form of fire. Even astronomers use words that reinforce the idea, saying that stars "burn" nuclear fuel to make light and heat. Of course the burning doesn't much resemble the chemical process on Earth that causes wood to burn — stars shine by fusing lightweight atoms into heavier ones, creating energy by Einstein's famous formula, $E=mc^2$.

But recent research hints that the process of star formation does, in some respects, resemble the way a wildfire burns. A team of astronomers from the United Kingdom, Australia, and Spain used the Hubble Space Telescope to examine the 9th-magnitude barred spiral galaxy NGC 2903, located just 25 million light-years away in the constellation Leo. The researchers were able to get a clear view into the galaxy's interior and found that stars were not forming where they expected.

Earlier observations had shown that NGC 2903's core had a complex, speckled

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| Pictor 201XT | 399 |
| Pictor 208XT | 499 |
| Pictor 216XT | 699 |
| Pictor 416XTE | 1999 |
| Pictor 616 filter | 699 |
| Piggy brkt 7/8" | 34 |
| Piggy brkt 10" | 34 |
| Piggy brkt 12" | 50 |
| Prism 2" 90° | 105 |
| Prism 1.25" 90° | 45 |
| Prism .96-1.25" | 32 |
| Prism 1.25" 45° | 45 |
| Skylight/seal | 50 |
| Tele ext-variable | 40 |
| T-adapt: SCT | 30 |
| T-adapt: vari-proj | 40 |
| T-adapt: 1.25" | 30 |
| Vari pol 905 | 50 |
| Weight set 7" or 8" | 92 |
| Weight set 10" | 99 |
| Weight set 12" | 109 |
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| Easy Tester | 32 |

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| Skylight red/white | 30 |
| Quickfinder | 40 |

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| Astro Chair | 160 |

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| GM-8 w/motor | 1465 |
| G-11 w/motor | 1895 |
| Dove plate 8"-11" | 90 |
| Dove plate 12" | 135 |
| 125mm ring set/2 | 160 |
| DCM mount | 80 |

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| ETX-90 | 82 |
| ETX-125 | 104 |
| NexStar-5 | 104 |
| 6" full aperture | 119 |
| 8" full aperture | 139 |
| 10" full aperture | 159 |
| 12" full aperture | 189 |

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### Dew Removers

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| 12v Controller | $70 |
| 110v adapter | 65 |
| 1.25" heater | 37 |
| 2" heater | 39 |
| 3" heater (ETX) | 42 |
| 7/8" heater | 52 |
| 9"/10" heater | 62 |
| 12" heater | 72 |

### Dew Shields!

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| ETX-90mm | 27 |
| 7"/8" | 54 |
| 10" | 64 |
| 12" | 85 |

### Kwik Focus!

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| ETX-90 or 125 | 33 |
| 8" | 47 |
| 10" | 57 |

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| Hard case N8 | 249 |
| RS232 cable | 35 |
| Solar glass 80 | 68 |
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| **9x63 Ultima** | 359 |
| **10x50 Ultima** | 259 |
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| The Sky L2 PC | $129 |
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| BinoVue | 1030 |
| TelePod w/tripod | 365 |
| Paracorr 2" | 235 |
| Zoom 8-24mm | 214 |

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| 20 or 25mm | 97 |
| 32 or 40mm | 114 |
| 55mm | 230 |

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| 19mm | 240 |
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**Nagler-82°**

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| 31mm Type5 | 599 |

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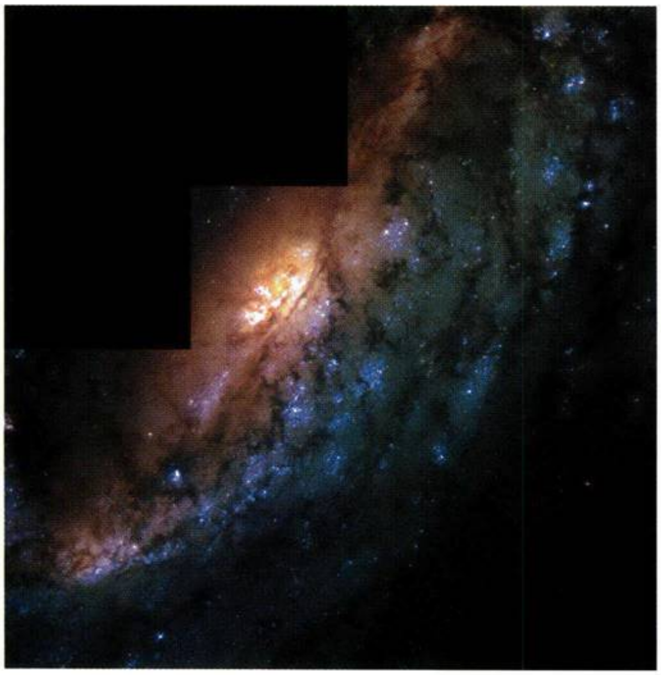

ESA and NASA

**The spiral galaxy NGC 2903 contains many bright blue star clusters, but a new Hubble image surprisingly shows they don't coincide with areas of star birth.**

appearance, full of "hot spots." Hubble was able, for the first time, to resolve those hot spots into individual star clusters, apparently born between 5 million and 10 million years ago. But surprisingly, the greatest amount of star formation seems to be taking place in interstellar clouds located a fair ways from the young clusters.

"The most striking feature of the Hubble images is that star formation seems to occur in large regions of ionized hydrogen distributed in a mighty, 2,000-light-year-wide ring around the center of the galaxy," says team member Almudena Alonso-Herrero of the University of Herfordshire in the United Kingdom. This ring appears as a whitish glow around the center of the Hubble image.

Astronomers see similar rings around the cores of other galaxies and think they represent interstellar gas falling in toward the galaxy's center. The researchers suggest that the bar in NGC 2903 funnels gas inward and helps trigger the star birth.

The gap between the young clusters and the glowing hydrogen clouds means that the star-forming activity is shifting from place to place. "It's moving surprisingly fast, about a million kilometers (600,000 miles) a year on average," says team member Stuart Ryder of the Anglo-Australian Observatory in Sydney, Australia.

"Star formation may be like a wildfire," he adds. "Once it has burned out an area, it has to move on to where there's more fuel or it will die out." He suspects that newly formed massive stars in one region explode, sending shock waves into neighboring clouds that trigger a new round of star formation. — R. T.

## MIR Comes Down in Blaze of Glory

Launched in 1986 during the height of the Cold War, the MIR space station gave the Soviet Union (and later Russia) bragging rights to the human use of near-Earth space. But with advancing age and a deteriorating economy back home, the space station simply became too expensive to keep aloft. On March 23, Russian controllers ignited MIR's rocket thrusters and directed the craft to a fiery reentry over the South Pacific. After several years of accidents and breakdowns, including a fire and the crash of a cargo ship, the maneuver went flawlessly. Residents of Fiji were even treated to the sight of the spacecraft breaking apart and glowing pieces streaking across the sky. For MIR — at 135 tons, the largest object ever to orbit Earth (not counting the moon) — it proved a fitting end to a spectacular life.

NASA

**The MIR space station, as seen from the space shuttle.**

## Pluto Mission Bites the Dust

The only planet in the solar system not yet visited by a spacecraft will remain that way indefinitely, after NASA axed a long-planned mission to Pluto and the Kuiper Belt from the space agency's 2002 budget. "We wanted the funds to mount a more aggressive — and realistic — Mars exploration program," said NASA Administrator Daniel Golden at an April news conference. "We got the funds, but the offset came from canceling Pluto Kuiper Express and the Solar Probe mission. This is one example of the type of priority reexamination that is going on at NASA, as encouraged by the president, and personally, I think that's the way it ought to be."

## Mars Odyssey on Its Way

Amid all the recent bad news about exploring space, NASA is also seeing some good. On April 7, the 2001 Mars Odyssey spacecraft successfully lifted off from Cape Canaveral, embarking on a journey that will arrive at the Red Planet on October 24. Mars Odyssey will use three instruments to map the chemical and mineralogical makeup of the planet; an imaging system that can take thermal and visible-light photos; a gamma-ray spectrometer to measure the subsurface composition and look for signs of water; and a radiation experiment designed to measure the potential hazards that might face any future astronauts.

NASA

**Mars Odyssey blasts off on April 7 from Cape Canaveral.**

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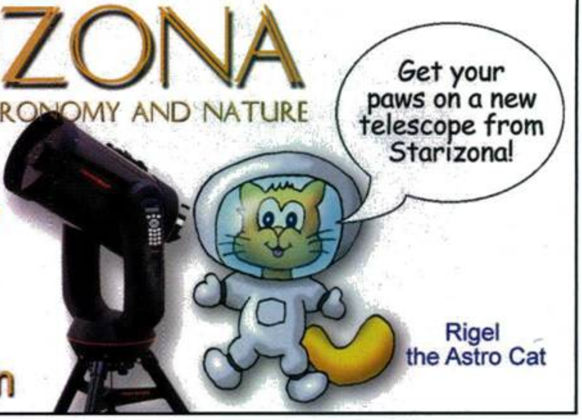
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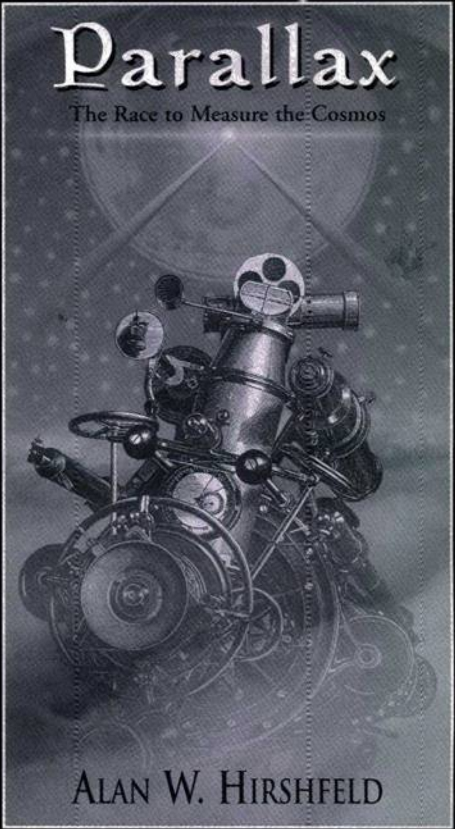

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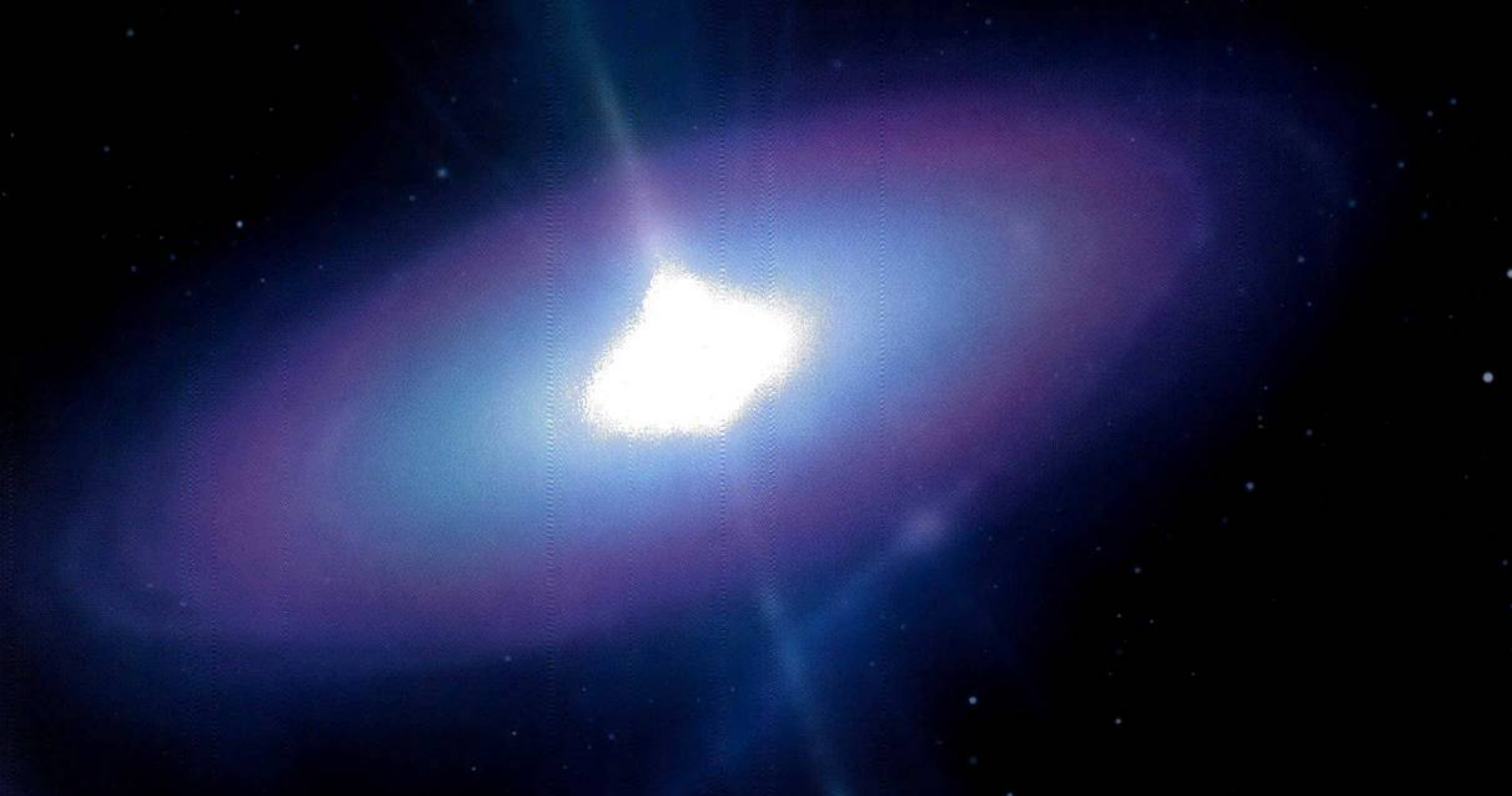
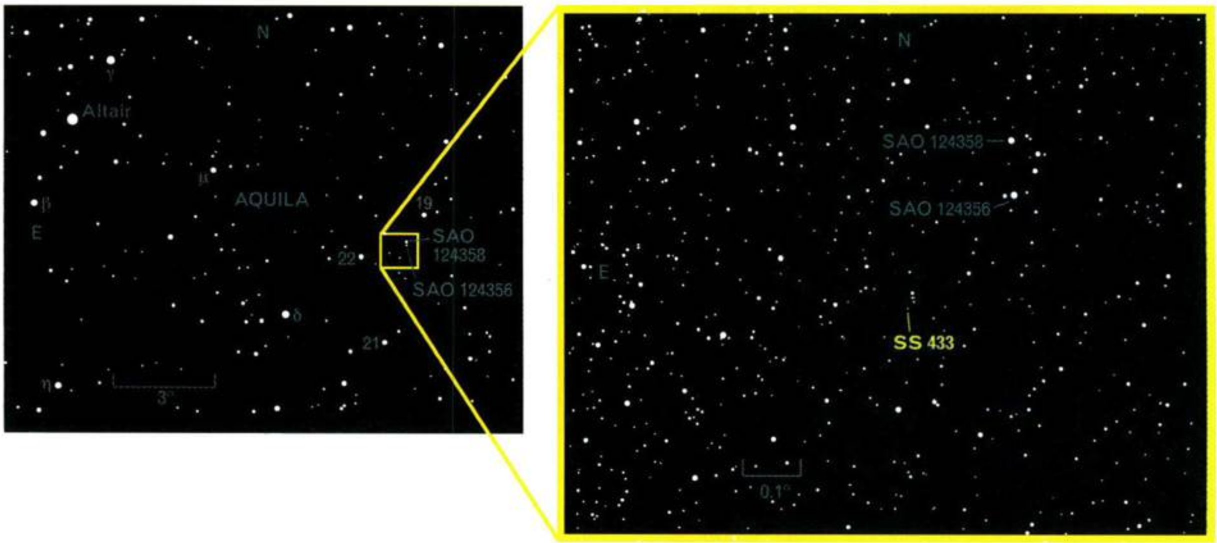


*Beaming high-energy jets across the galaxy, microquasars offer a nearby laboratory for studying nature's most powerful objects.*

Perched near the edge of the known universe, quasars rank among the most powerful beasts known. So much visible light and ultraviolet radiation pours from these cosmic powerhouses that they often outshine the entire galaxy that hosts them. Yet most of this radiation comes from a region not much bigger than our solar system. Modern science knows only one process potent enough to power these brilliant quasars. That process is accretion, and the driving force — right at the center of each host galaxy — is a supermassive black hole millions or even billions of times more massive than the sun.

Most astronomers are now convinced that a vast accretion disk of gas and dust, the gravitationally shredded remains of countless stars and nebulae, surrounds the black hole in a quasar. As the gas in the disk spirals toward the black hole's deadly maw, the material becomes

## Track Down a Microquasar



There isn't a single microquasar that shines brightly. You won't track one down with your naked eye or binoculars — you might even have trouble doing it with a telescope. But if you have an 8-inch or larger scope and enjoy hunting for exotic quarry, a microquasar could be the ticket.

The brightest microquasar in the sky is SS 433, the first to be discovered. It glows at magnitude 14.1 — slightly fainter than Pluto — and lies in a crowded field in the constellation Aquila. Summer and autumn are the best times to spot the elusive SS 433, which lies 4° northwest of the 3rd-magnitude star Delta (δ) Aquilae (which in turn lies 8.5° southwest of Aquila's brightest star, 1st-magnitude Altair). Aquila rises in the early evening in July and appears highest in the south a little after midnight. By September, you can find it due south around 9 P.M.

Carefully match what you see in the eyepiece with the map above, which shows stars to magnitude 14.5. Once you do, you should be able to pick out SS 433. Don't expect any detail — no telescope will show it as more than a dim point of light. But just glimpsing the light of one of the galaxy's most exotic objects will be worth the effort. — *Richard Talcott*

so compressed and heated that it generates the truly enormous quantities of light that make quasars conspicuous across billions of light-years. And that's not the only remarkable facet of their behavior. For reasons still not fully understood, many quasars blast highly collimated jets of charged particles millions of light-years into space.

Since the first quasar was discovered in 1963, astronomers have aimed their instruments at these deep-space enigmas to try to learn more about their gas-guzzling black holes and the physics that occur in this cosmic digestion. But it hasn't been easy. The trouble: Quasars simply lie so far away that detailed studies of them pose enormous difficulties.

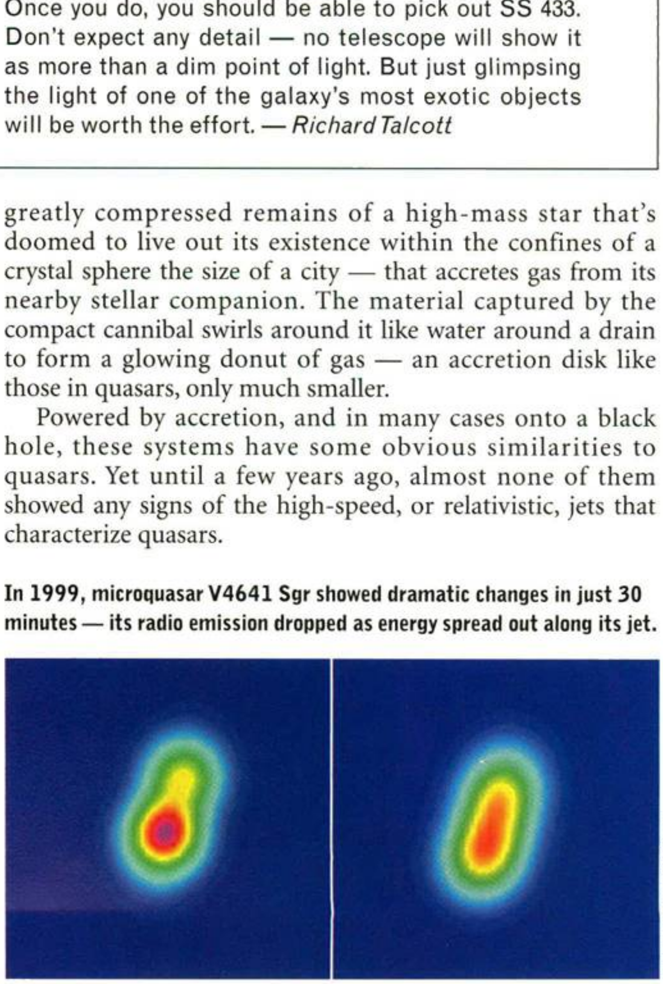
What astronomers needed was a nearby quasar, or at least something that mimicked its exotic behavior. Fortunately, that's just what they have found. Research has uncovered a new class of jet-emitting objects that operate on an identical principle to quasars, only on a vastly smaller scale — and almost literally lie in our own Milky Way backyard. These galactic "microquasars" glow brightest in x rays and spew high-energy jets that can be seen across the galaxy.

### An Unexpected Discovery

Since the first celestial x-ray source, Scorpius X-1, was discovered by a rocket-borne experiment in 1962, astronomers have uncovered 200 to 250 interacting star systems that produce prodigious amounts of x rays. These x-ray binaries contain either a black hole or neutron star — the greatly compressed remains of a high-mass star that's doomed to live out its existence within the confines of a crystal sphere the size of a city — that accretes gas from its nearby stellar companion. The material captured by the compact cannibal swirls around it like water around a drain to form a glowing donut of gas — an accretion disk like those in quasars, only much smaller.

Powered by accretion, and in many cases onto a black hole, these systems have some obvious similarities to quasars. Yet until a few years ago, almost none of them showed any signs of the high-speed, or relativistic, jets that characterize quasars.

**In 1999, microquasar V4641 Sgr showed dramatic changes in just 30 minutes — its radio emission dropped as energy spread out along its jet.**



R. M. Hjellming, NRAO, AUI

The lone exception was a system called SS 433 in the constellation Aquila the Eagle. For more than ten years, SS 433 remained the only such object to show relativistic jets. That's because it's conspicuously bright in visible light, standing out like a beacon compared with most x-ray sources. SS 433 thus became the first known microquasar, even though it wasn't the first such system to be ennobled with that term. These objects proved to be so unusual that the name "microquasar" didn't come into use until 1992.

It was then that Félix Mirabel of the Center for Studies in Saclay, France, and Luis Rodríguez of the National Autonomous University in Mexico City discovered two odd sources near the galactic center, 1E1740.7–2942 and GRS 1758–258. When observed at radio wavelengths, these sources looked remarkably similar to those quasars that emit strongly in the radio. They showed dense central condensations with extended lobes of radio emission protruding from either side — very probably jets of some sort. But the new objects persistently emitted very high-energy, or hard, x rays, something unknown in quasars. The sources had x-ray spectra and luminosities comparable to that of the famous x-ray binary called Cygnus X-1, and the intensity of their emission varied over similar periods. They almost certainly belonged to our galaxy, and very probably were x-ray binaries.

Recent studies with the Rossi X-ray Timing Explorer (RXTE) satellite appear to confirm this. If astronomers have interpreted the new data correctly, GRS 1758–258 seems to be a black hole orbiting an orange giant star once every 18.45 days. Meanwhile, the companion to the suspected black hole in 1E1740.7–2942 has not been confirmed, but with a presumed period of 12.7 days, it must also be a giant star to be big enough to spill material onto its compact partner.

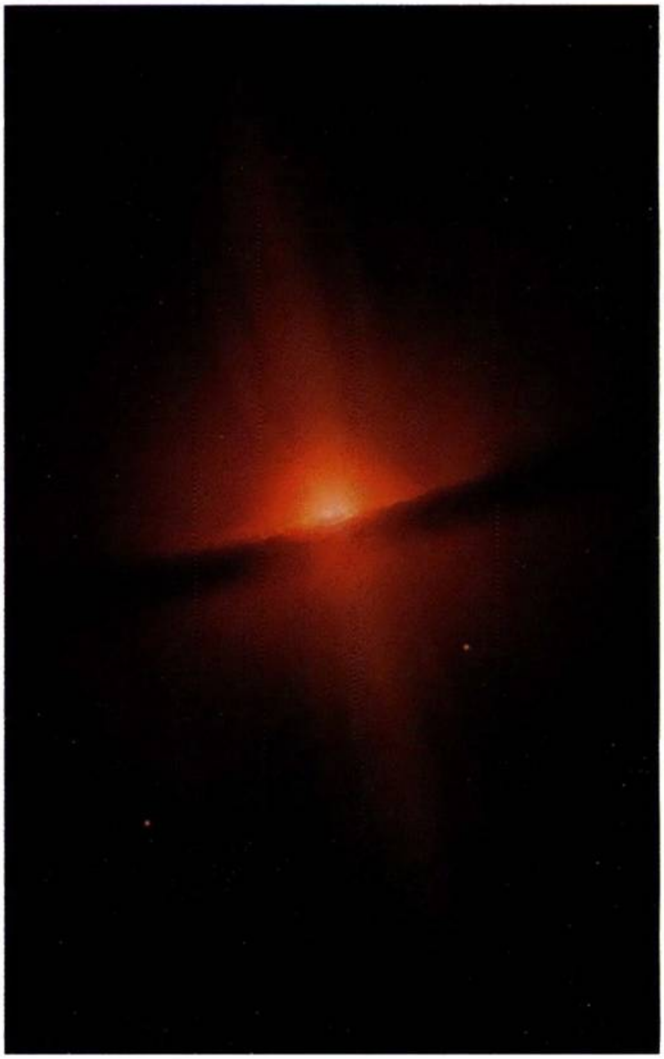
In a paper written for the *Annual Review of Astronomy and Astrophysics* in 1999, Mirabel and Rodríguez described how they picked the name for this new class of galactic object. "Microquasar was chosen to suggest that the analogy with quasars is more than morphological," they wrote, "and that there is an underlying unity in the physics of accreting black holes over an enormous range of scales, from stellar-mass black holes in binary systems, to supermassive black holes at the center of distant galaxies." And so it was that microquasars were born.

## The Eruption of "Old Faithful"

In 1994, two years after the discoveries of 1E1740.7–2942 and GRS 1758–258, Mirabel and Rodríguez hit upon the fourth microquasar. This was another source in Aquila, called GRS 1915+105, found and studied in 1992 with the Russian x-ray satellite GRANAT. Located 40,000 light-years from Earth, GRS 1915+105 is a so-called transient hard x-ray source — occasionally its hard x rays dip to a lower intensity, but they always return to full power. No jets are seen at x-ray energies, and when the source was discovered in 1992 it wasn't bright enough to be observed at radio wavelengths. But in 1994 its radio output suddenly flared. Mirabel and Rodríguez picked up the trail with the Very Large Array radio telescope in New Mexico and saw that GRS 1915+105 was ejecting massive "blobs" of plasma into space.

Three years later, GRS 1915+105 came under the spotlight again. A team of researchers led by British astronomer Rob Fender, now based at the University of Amsterdam, noticed that in addition to its radio emission, GRS 1915+105 was blasting smaller blobs of infrared-emitting material into space. Around the same time, Fender and his collaborator, Cambridge University's Guy Pooley, noticed an intriguing relation between the x-ray emission and the radio and infrared blobs. Every half hour or so, the x rays suddenly and dramatically decreased in intensity, and at the same time jets appeared in the radio and infrared. Five minutes later, the x rays returned to full strength and the jets turned off.

Pooley and Fender think that the accretion disk in GRS 1915+105 periodically fills up with material stolen from the companion by the black hole. Normally the disk emits x rays by virtue of accretion, but once the disk becomes sufficiently full, after half an hour, the system somehow blasts the inner portion of the disk into space. At this point the x rays rapidly diminish — they can't be produced so easily when there's no accretion disk — and the ejected material forms the radio and infrared jets.



**Quasars and microquasars aren't the only objects with jets. Here a pair of jets emanate from the protoplanetary disk surrounding a young star.**

This periodic activity prompted one astronomer to dub GRS 1915+105 a cosmic "Old Faithful," after the famous geyser in Wyoming's Yellowstone National Park. In the words of another astronomer, Jean Swank of NASA's Goddard Space Flight Center, "Every half-hour, the black hole in the constellation Aquila throws off the mass equal to that of a

100-trillion-ton asteroid at nearly the speed of light. This process clearly requires a lot of energy — each cycle is equivalent to six trillion times the annual energy consumption of the United States."

GRS 1915+105 also gained notoriety by being the first microquasar whose jets appeared to be moving faster than the speed of light. Such "superluminal expansion" is a feature seen in many quasar jets. Of course, the special theory of relativity forbids such speeds, and it turns out that superluminal expansion is merely an optical illusion. Still, the jets in GRS 1915+105 do move rather quickly — at more than 90 percent the speed of light.

Shortly after the superluminal motion in GRS 1915+105 was announced, two independent teams of astronomers picked up another case. In 1995, the Compton Gamma Ray Observatory discovered that source, dubbed GRO J1655–40. And three years after that, another group observing with RXTE found what may be a third superluminal source: XTE J1748–288. In total, about a dozen microquasars are now known.

## Big Brother *vs.* Little Brother

No one now doubts that quasars and their relatively microscopic cousins operate on the same principle of accretion. In each case, a vast disk of material surrounds a compact object. Friction and compression near the inner edge of an accretion disk heats the material to high temperatures. And both classes of objects emit jets of charged particles deep into space at incredibly high speeds, approaching that of light. (How these beams manage to escape the powerful gravity of a black hole still puzzles astronomers.)

Yet huge differences exist between quasars and microquasars, not the least of which is their size. Quasars contain black holes with a mass of millions or even billions of suns. In microquasars, the black holes are stellar corpses with much less foreboding masses, between 3 and 20 times that of the sun. And some microquasars are powered by neutron stars and not black holes. Scorpius X-1 and Circinus X-1 certainly harbor neutron stars, while SS 433, Cygnus X-3, and CI Camelopardalis may.

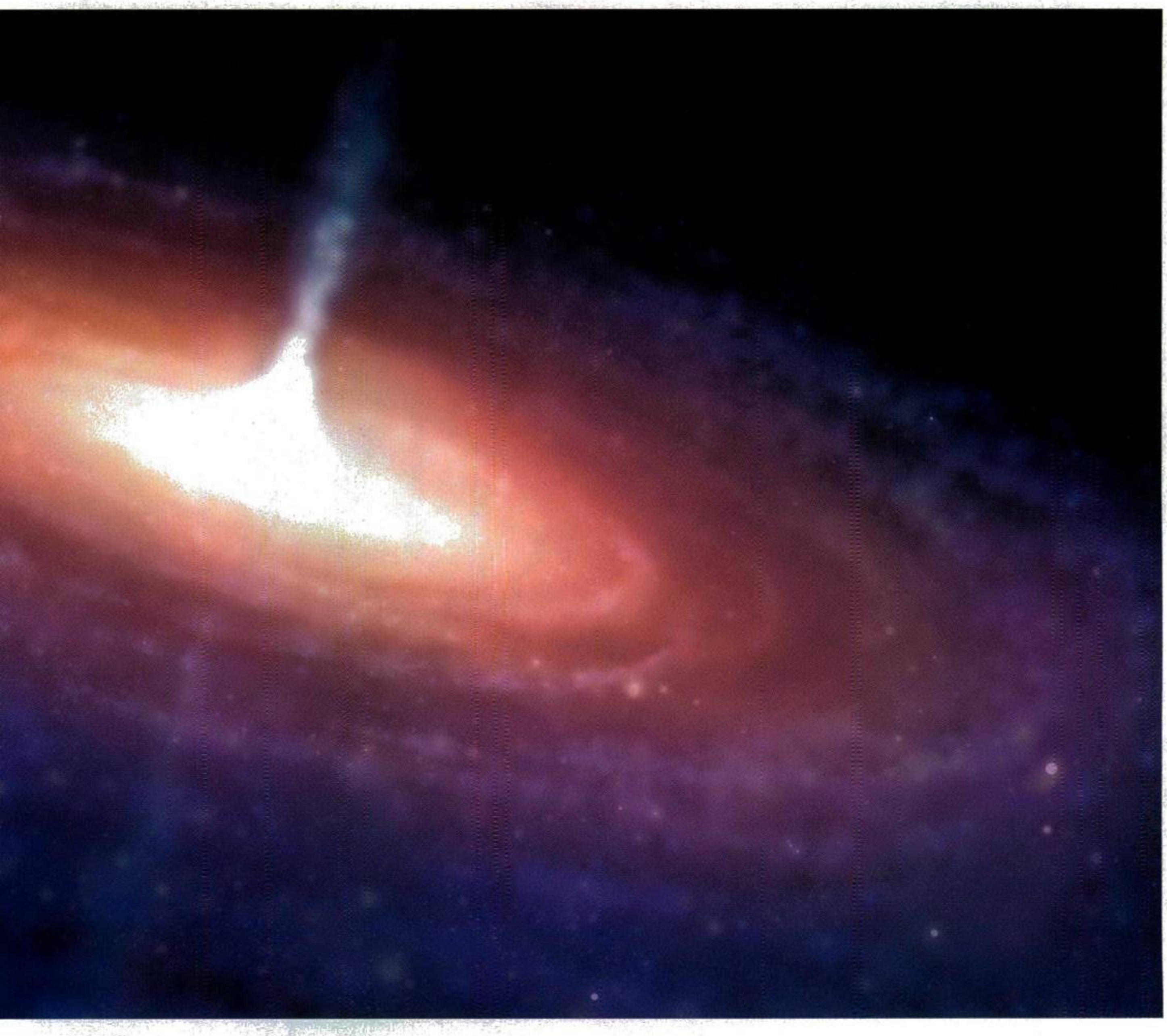
The far greater mass of the black hole in a quasar means that the accretion disk is also much larger and more massive and formed differently than the accretion disks seen in microquasars. A typical quasar accretion disk might stretch as far from the black hole as the orbits of the outer planets do from the sun. These disks contain the remains of stars and nebulae netted by the black hole from the surrounding galaxy — or they may even have been created along with the galaxy itself. The black hole in a typical quasar swallows around a sun's worth of material every year.

In microquasars, by contrast, the accretion disks measure only thousands to perhaps hundreds of thousands of miles across. These are created when the compact object feeds off its unlucky companion star — a relatively puny one-billionth of a solar mass per year. The jets in both quasars and microquasars move extremely fast and appear highly collimated, but they exist on vastly different scales. A quasar's jets blast for millions of light-years into space — millions of times deeper than a microquasar's jets.

*Scales* aside, quasars and microquasars exhibit other clear differences. The disks in quasars have inner temperatures of a few thousand degrees. At these temperatures, they primarily emit ultraviolet, optical, and infrared radiation, though they sometimes venture into the x-ray and radio region as well. Microquasar disks grow far hotter, making them predominantly x-ray objects. In neutron star systems, the inner disk temperature ranges in the millions of degrees, while the black hole systems become even hotter. That's because the material can get closer to the center of gravity of a black hole than it can to that of a neutron star, which is larger. The greater infall distance means that more gravitational potential energy gets converted into kinetic energy, producing more heat. Moreover, because microquasars are so much smaller than their extragalactic brothers, dynamic events in the disk can happen in mere minutes — such events in quasars may span thousands of years.

## In the Future

In just eight years, the number of confirmed galactic microquasars has grown from 1 to 12. Less than two years ago, Robert Hjellming of the National Radio Astronomy Observatory — in collaboration with researchers from the



**High-speed jets of charged particles race from a galactic microquasar, a relatively nearby object with many important similarities to quasars.**

Massachusetts Institute of Technology — found a microquasar called V4641 Sagittarii. At its x-ray peak, V4641 Sgr ranked as the brightest x-ray source in the sky. Preliminary research suggested that it harbored a black hole and resided a mere 1,600 light-years away, which would have made it the closest known black hole to the sun. But astronomers are no longer certain of the distance. An alternative optical counterpart to the x-ray source has been located, and it is much farther away — 20,000 light-years.

The most recent addition to the microquasar list goes by the designation LS 5039. It lies about 9,100 light-years from Earth and its jets travel at 20 percent the speed of light while extending more than 1.5 billion miles (2.5 billion km) into space. And uniquely among microquasars, at least so far, this one emits high-energy gamma rays.

Such was the importance of the discovery of microquasars that Félix Mirabel and Luis Rodríguez were awarded the Bruno Rossi Prize in 1997, just five years after they christened the microquasars. The High Energy Astrophysics Division of the American Astronomical Society awards this prize for a significant contribution to high-energy astrophysics. With the appearance of better x-ray observatories, more and more of these systems are bound to come to light. Indeed thousands of undiscovered microquasars may turn up in the Milky Way Galaxy alone. With so many prospective accreting black holes located relatively nearby, astronomers should have all the laboratories they need for detailed investigations into quasars and their enigmatic jets. ◼

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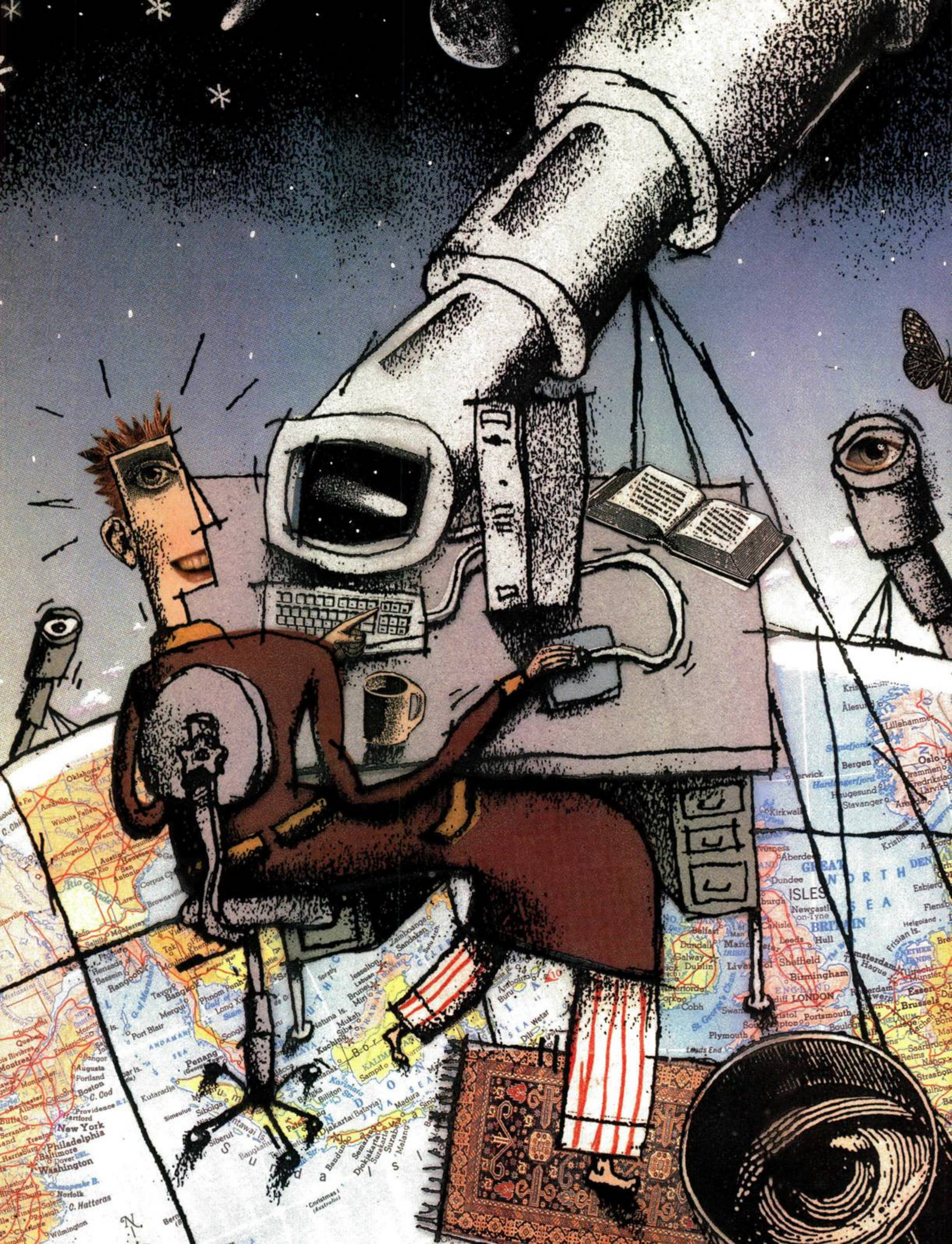
*Mark A. Garlick is a freelance writer, illustrator, and former astronomer based in Brighton on England's south coast. He is currently writing and illustrating his first book,* Story of the Solar System. *You can see more of his paintings and digital artwork on-line at http://www.space-art.co.uk.*



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Hartford
New York
Philadelphia
Baltimore
Dover
Washington
Chesapeake B.
Norfolk
C. Hatteras
Wilmington
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# Cybertrackers

## Use your computer to make discoveries in the image archives of the world's biggest telescopes.

**by Mark Sincell**

Finding comets is Michael Oates's bag, baby. "When I find one I react as though it's a total shock," says Oates. "I get a sinking feeling in the stomach, my heart starts to pound, I break out in a cold sweat, and I start shaking." Even after finding more than 100 of them, the thrill never fades for the world record holder. It makes Oates wonder how he survived June 6, 2000: He discovered six comets that day.

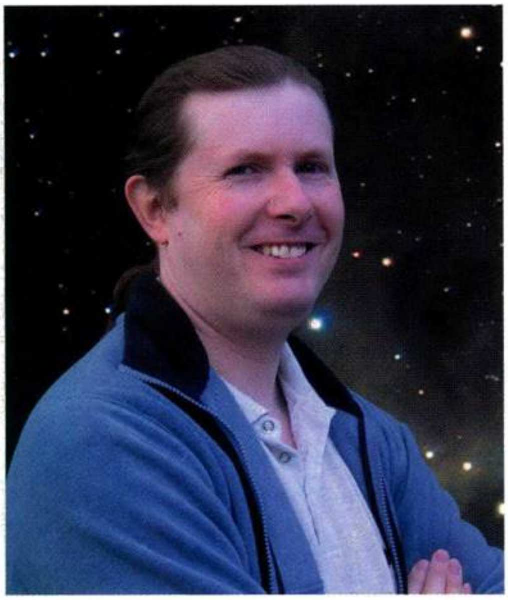
Daily, Oates downloads more than 100 megabytes of data collected by the Solar and Heliospheric Observatory (SOHO), a $1.2 billion mission operated by the European Space Agency (ESA) and NASA that has been staring at the sun for five years. Three of the spacecraft's instruments collect data on the sun's interior and five more study its atmosphere using coronagraphs — devices that use occulting disks to artificially eclipse the sun to prevent its light from swamping their views.

Mike Waraksa

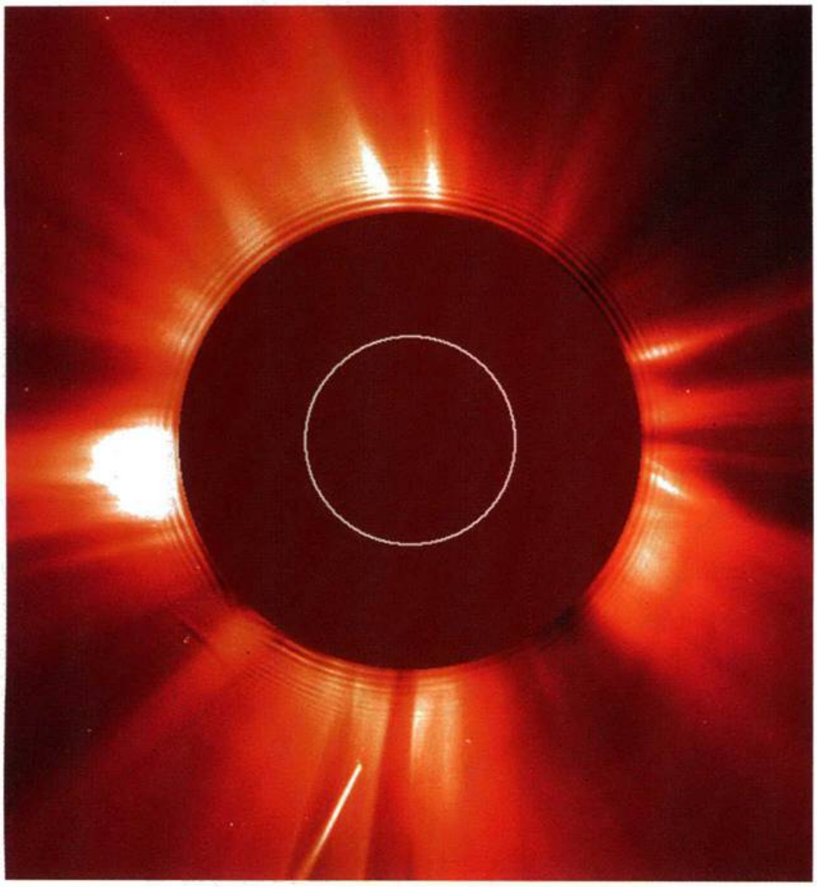
SOHO's cameras also spot sungrazers, comets that penetrate the corona and vaporize like water droplets hitting a hot skillet.

Oates stitches SOHO images together on his computer to make animations of sungrazers before they go pppffffffffT. "I see them disappear into the corona, never to be seen again," says Oates. "It's just a pity."

Despite his accomplishments, Oates is not paid by ESA or NASA. He has never applied for SOHO observing time, and he doesn't publish his results in scientific journals. He is not even a professional astronomer. The amateur had not discovered a comet during 15 years of observing from near his home in Manchester, England. Then he learned about SOHO at a January 29, 2000, meeting of the Society for Popular Astronomy. "Within a week I had discovered my first comet," he says.



**Michael Oates never dreamed of discovering a comet, let alone 100 of them, until he became a cybertracker.**



NASA, SOHO

**This sungrazer comet, C/2000 H2 SOHO, was spotted by Oates and three SOHO researchers.**

## Sipping from a Fire Hose

Astronomer Doug Biesecker of the SOHO science team at the Goddard Space Flight Center in Greenbelt, Maryland, regularly scans SOHO images for comets. However, he doesn't always have time to do it right away. Since the images are posted online almost as fast as they arrive from the spacecraft, amateurs such as Oates can do SOHO's sleuthing and receive joint credit for discoveries.

Intrigued? Think about letting someone else do the bone-chilling, sleep-depriving work of gathering images. Imagine replacing your venerable 8-inch reflector with a suite of state-of-the-art telescopes including the Palomar 200-inch telescope, the Hubble Space Telescope, and the Very Large Array. It's not a dream. For the price of a personal computer and a modem, you can have all that and more. Welcome to virtual astronomy.

Charge-coupled devices (CCDs), sensitive, electronic light detectors that generate digital images, and more powerful computers, now supply amateurs and professionals alike with a flood of digital data. Telescopes around the world are contributing to the deluge. "It's effortless to collect the data, a bit like drinking from a fire hose," says Gregory Henry, a Tennessee State University astronomer. He monitors variable sun-like stars with the Fairborn Observatory in southern Arizona, but doesn't have enough time to analyze all the data that he collects. "I could never do it all alone," says Henry.

John Percy, an astronomer at the University of Toronto, had the opposite problem: high school students eager to analyze astronomical data, but no data. When Henry mentioned to Percy that he was looking for a collaborator, Percy talked to one of his students.

David Kolin was a senior in high school with no astronomy experience when Percy invited him to spend the summer of 1999 studying the yellow supergiant variable star Rho Cassiopeiae. Kolin, a cheerful 6-footer with a permanent smile on his face, downloaded Henry's data, collected over 12 years, as well as data from the American Association of Variable Star Observers. The student plotted variations in the star's color and brightness over time, and his curiosity about variable stars grew. He read technical papers and books trying to better understand them.

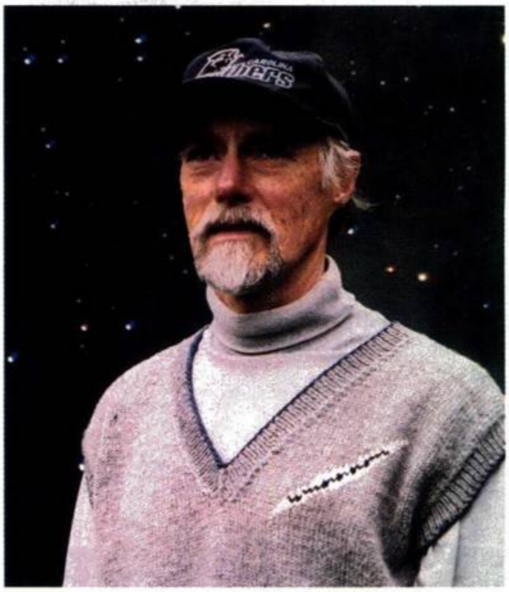
By summer's end, Kolin's homework had paid off: He discovered a complex 820-day pulsation cycle with less significant periods of 380, 510, and 645 days. As the star swells and shrinks during the final stage in its life, its color oscillates from yellow to reddish and back to yellow. The changes result from the repeated ejection of gas during the in-and-out surging of Rho's puffed-out atmosphere. Kolin, Percy, and Henry coauthored a paper on their work in the March 2000 issue of the *Publications of the Astronomical Society of the Pacific*. "I loved learning by doing actual research," says Kolin, now a student at McGill University in Montreal. "Reading about astronomy is one thing, but this was much more interesting."

## Hands-On Learning

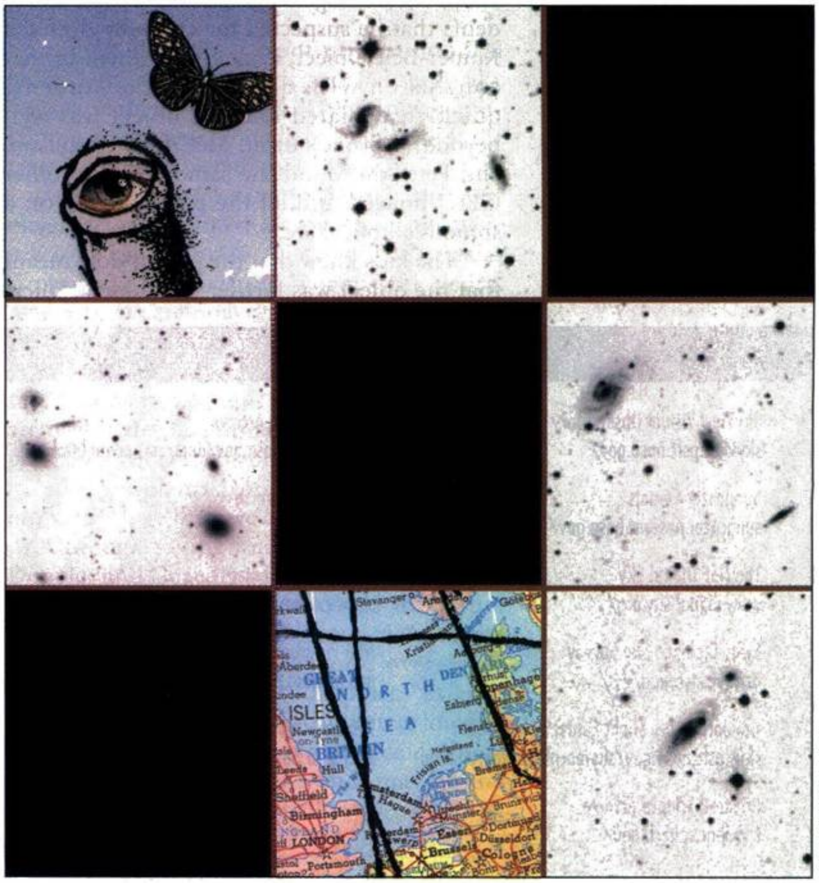
Heather McCurdy knows the feeling. A senior at Northfield Mount Herman School in Northfield, Massachusetts, and a member of the swim team, McCurdy was merely looking for extra science credits when she enrolled in "Introductory Astronomy." At the time, the teacher of the course, Hughes Pack, was using images and lessons provided by The Hands-On Universe (HOU). Carlton Pennypacker, an astronomer at the University of California at Berkeley, ran that project. He used it to teach students how to analyze astronomical data, not to make big discoveries.

After only a few days of class instruction, McCurdy, Miriam Gustafson, and George Peterson — students at the private coed boarding school — began downloading and analyzing digital images taken by the Cerro Tololo Interamerican Observatory's (CTIO's) 4-meter (157-inch) telescope in Chile. The telescope had collected multiple images of a large swath of sky in order to detect the transient brightening of distant supernovae. The images were sent to the Supernova Cosmology Project at Lawrence Berkeley National Laboratory in California as part of its effort to measure the expansion of the universe. Cosmology Project astronomers have no interest in solar-system objects, but Pennypacker realized that the CTIO images — with objects as faint as 24th magnitude — would reveal asteroids and icy objects in the Kuiper Belt, a disk-shaped region beyond Neptune that is a reservoir for most short-period comets.

"Every day we downloaded pictures off the Internet," says McCurdy. And every day she and their "Introductory Astronomy" classmates had little trouble discovering streaks of light left by asteroids in the CTIO images. On October 30, 1998, McCurdy and Gustafson spotted a peculiar pair of dots on a computer screen. They generated the dots by subtracting the light sources in one image from another image of the same patch of sky taken a couple hours later. The subtraction wasn't perfect: It left a mostly grayish background with a few obvious artifacts. However, the subtraction image was good enough so that the students were able to spot the unusual pair of dots. One dot was black, suggesting that an object on the

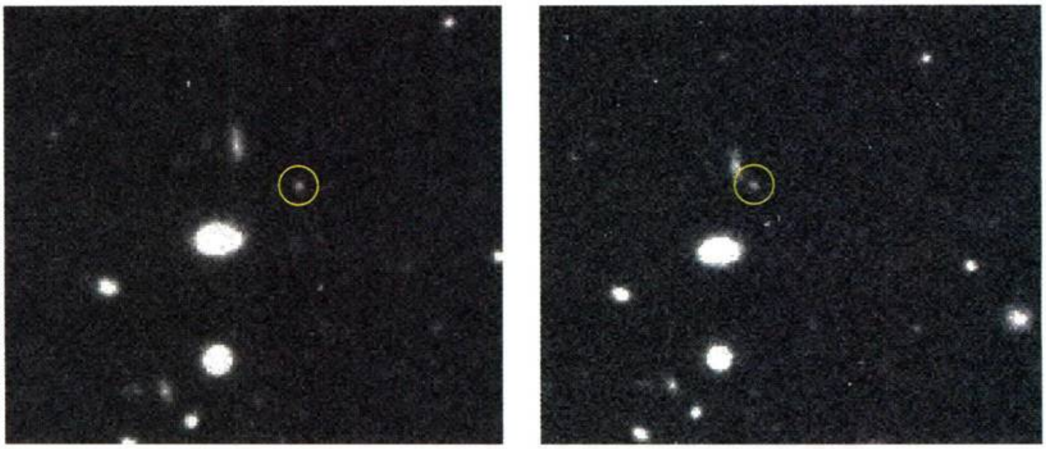


**Miles Paul's favorite telescope is a 20-inch reflector, but he also observes deep-sky objects online.**



**SkyView, an online archive created by astronomer Thomas McGlynn, is full of galaxy trios.**

StScI, Royal Observatory



Three students downloaded these images from a digital archive and discovered a faint Kuiper Belt Object.

CTIO, Supernova Cosmology Project, HOU

first image had disappeared from the second. And a white dot was visible about 1 centimeter from the black dot, indicating that the same object had merely changed position. They were seeing a single, faint object well beyond the Main Asteroid Belt. "The hair on the back of my neck stood up," recalls Pack.

Nearby asteroids make streaks of light in many of the long-exposure CTIO images due to parallax, the apparent movement of sky objects caused by Earth's orbit about the sun. Solar-system objects farther away than asteroids appear to move less — the parallax is smaller. Instead of streaks on time-exposure images, these more distant objects appear as closely aligned pairs of black and white dots in subtraction images. Instead of telling his students that he suspected they had discovered a Kuiper-Belt Object, Pack guided them to that conclusion with questions. The students quickly calculated that the object was well beyond Neptune's orbit. McCurdy, Gustafson, and Peterson found the same object in other CTIO images, and all the positions fell on a smooth elliptical arc.

"The kids knew that the pair of dots meant that the object was farther out than a typical asteroid," says Pack. Three nights of follow-up observations and an orbit calculation by Brian Marsden, director of the Central Bureau of Astronomical Telegrams in Cambridge, Massachusetts, showed just how far away it was: beyond Pluto. The students had found one of the first 100 known Kuiper Belt Objects.

## An Information-Rich Revolution

Edwin Hubble once painstakingly measured the displacement of discrete lines of radiation from individual galaxies toward longer, or redder, wavelengths, which was explained by the movement of the galaxies away from Earth and each other. It was the first evidence that the universe is expanding. Now, the Sloan Digital Sky Survey (SDSS) churns out galaxy redshifts by the millions. The $80-million SDSS project will eventually observe and categorize hundreds of millions of celestial objects over a quarter of the entire sky. Astronomers at other observatories are conducting similar surveys. On a smaller scale, robotic telescopes continuously monitor the night sky on the lookout for Earth-crossing asteroids and faint flashes of light emitted by supernovae and gamma-ray bursters.

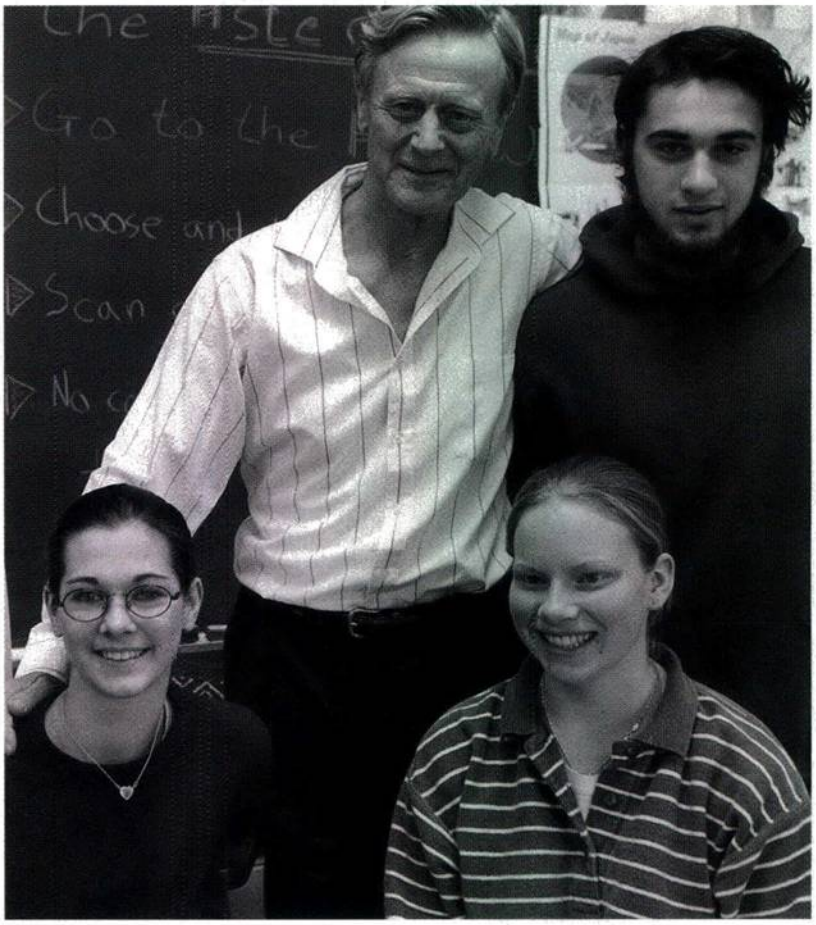
Alone, each project is interesting, but together they are revolutionary. "These data sets are so information-rich, they will enable science in ways that those who created them never imagined," says Caltech astrophysicist George Djorgovski. The trouble is getting the information in the hands of scientists; the data are stored in different computer databases around the world. So an international team of astronomers, physicists, and computer scientists is proposing a new way to do astronomical research.

It's called the National Virtual Observatory (NVO). It will link the world's digital-astronomy archives into a single distributed database that is available to anyone with a computer and an Internet connection. When it is

### Where to Get Started

| | |
|---|---|
| SkyView Virtual Observatory | skyview.gsfc.nasa.gov/ |
| Sungrazer Comets | sungrazer.nascom.nasa.gov/ |
| The NSF Digital Sky | www.digital-sky.org/ |
| STScI Digitized Sky Survey | archive.stsci.edu/dss/ |
| Goddard Space Flight Center's SkyMorph | skys.gsfc.nasa.gov/skymorph/skymorph.html |
| Infrared Science Archive | irsa.ipac.caltech.edu/ |
| HEASARC Data Archive | heasarc.gsfc.nasa.gov/docs/corp/data.html |
| Hands-On Universe | hou.lbl.gov/ |
| Minor Planet Center | cfa-www.harvard.edu/cfa/ps/mpc.html |
| NEO Program | neo.jpl.nasa.gov/ |
| Fairborn Observatory | 24.1.225.36/fairborn.html |

complete, it will contain virtually all of the raw data collected by every major astronomical program in the world. Instead of trekking to mountaintops to gather telescope data, virtual astronomers will be able to search through linked NVO databases and collect information from several observatories simultaneously. While the NVO is years away, the databases continue to fill.



**University of Arizona asteroid expert Tom Gehrels visits high school students Heather McCurdy, Miriam Gustafson, and George Peterson after their discovery of a Kuiper Belt Object.**

Glenn Minshall

## A Full SkyView

The virtual hunt for astronomical prey can make people do surprising things. Just ask Miles Paul. He taught Cell and Developmental Biology at the University of Victoria for more than 20 years before he retired six years ago and became a full-time amateur astronomer. "I am as busy as ever," says Paul. For his many nighttime observing trips, Paul's instrument of choice is a 20-inch f/4.5 reflector, but during the day it's SkyView, the online astronomy archive created in 1993 by Goddard astronomer Thomas McGlynn.

SkyView initially offered images from small surveys, and in 1994 began adding the Hubble Space Telescope's Digital Sky Survey, a 60-gigabyte database. SkyView grew during the 1990s. "Now we have 50 surveys covering 18 orders of magnitude in frequency," says McGlynn. Users can choose any point in the sky, or any object, and SkyView will produce a radio map or gamma-ray image of the region. Paul uses SkyView to locate and catalog his favorite nighttime sights, compact galaxy trios.

Other amateur astronomers use SkyView to create planetarium shows. Arno Gnaedig and Andreas Doppler used SkyView to save Earth. Well, they didn't actually save it, but they did prove that Earth wasn't going to be struck by the asteroid 1999 AN$_{10}$. At least not soon.

The Massachusetts Institute of Technology's Lincoln Near Earth Asteroid Research (LINEAR) project first spotted the rogue asteroid on January 13, 1999. At first, an orbital calculation suggested the object was heading for Earth. Although there was no chance of a collision during AN$_{10}$'s next close encounter in 2027, a number of groups confirmed that 1999 AN$_{10}$ would miss Earth by a cosmic whisker — two-thousandths of the distance from Earth to the sun. And it could eventually swing closer. The relatively few observations left uncertainties in the orbital calculation, which prevented astronomers from ruling out a collision after 2027.

The uncertainty led cybertrackers Gnaedig, a 45-year-old engineer at a German communications company, and Doppler, a 37-year-old software engineer in Berlin, to help. Instead of trying to predict where AN$_{10}$ would be in the future, they ran their orbital calculations backward to determine where it had been. At the end of that calculated rainbow, they discovered a pot of astronomical gold. Buried in the digitized Palomar Sky Survey plate archive was a 1955 image containing a faint streak made by an asteroid; the team had "pre-covered" 1999 AN$_{10}$.

Adding the 45-year-old data to the new observations enabled astronomers to more precisely calculate AN$_{10}$'s orbit. The calculations bought Earth 50 worry-free years. Astronomers are now certain AN$_{10}$ won't collide with Earth before 2076. "The value of the digital-plate archives should now be clear," says Doppler. But he is concerned that most archival plates languish offline. "Only a small part of the world's astronomy archives are digitized," complains Doppler. "There is much more out there than we can even imagine."

Although saving humanity is great, both Doppler and Gnaedig admit to having another motivation for getting involved in virtual astronomy. And it is one that is close to the hearts of astronomers the world over. "It is weather independent," says Doppler. "Even in winter, we are warm at our computers looking at observations done by others in cold observatories." And that, in the end, may be the most compelling reason of all. ■

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*Astrophysicist and regular* Astronomy *contributor Mark Sincell lives in Houston, Texas.*

# DIGITIZING ASTRONOMY'S GLASS PLATES

*While CCDs laid classic photography to rest, old plates still hold keys to cosmic puzzles.*

by Anthony Misch

Toward the end of the 19th century, photography at the telescope began to reveal a previously invisible universe, ushering in a golden age of astronomy. The photographic plate became as indispensable a tool as the telescope itself. Every major observatory was equipped with darkrooms for developing plates, along with instruments for examining them. Over the decades, millions of glass plates were exposed at scores of observatories.

The arrival of the CCD in the early 1980s spelled the end of photography's preeminence in research astronomy; photographic plates have now all but disappeared from research. The CCD makes it easy to dismiss pre-electronic data as part of a quaint and inefficient past. But that view hides the importance that this vast collection of inherited data holds for future researchers. The medium, here, is most decidedly not the message, as the spectrum or image of a star remains indifferent to the means by which it is recorded.

Nowhere is the importance of inherited data more evident than in cases of stellar variability, where an early observation might provide the only record of some time-varying phenomenon in a star's recent history. Because the world's astronomical data form a continuous record, comprised of millions of observations and uncounted hours of telescope time, observations made 100 years ago are often critical in solving some of today's questions.

What we know about Eta Carinae relies on centuries-old data.

- Our understanding of Eta Carinae, the supermassive star with broad variability, jets, violent winds and circumstellar shells, relies importantly on century-old data and spectra taken in the 1940s.
- Violent variable stars of the FU Orionis type ("Fuors") can increase in luminosity a hundredfold in a few years, remaining bright for decades. The only spectrographic record of a Fuor in outburst is in the plate archive at Lick Observatory.
- A dying star, cooling toward oblivion, can suddenly expand and brighten when its helium shell ignites. An exposure taken at Lick 80 years ago recently led to the first publication of the spectrum of a helium flash star in its cool giant phase.
- 25 years of photographic spectra from Mount Wilson, Palomar Mountain, and the European Southern Observatory provided evidence of mass loss in giant and supergiant stars.
- The discovery of short-term changes in the ultraviolet spectrum of Arcturus provoked an investigation of 77 archived spectra from Mount Wilson, and led to the recognition that the phenomenon is by no means rare in red giants.
- Astronomers resolved a discrepancy in the mass of Procyon when sensitive new observations were combined with data from 250 plates spanning 83 years.
- The eclipsing binary star SS Lacertae ceased eclipsing around the middle of this century. The reanalysis of inherited data contributed to the recent solution of the mystery: the presence of a third member of the system.

Imagine that you are trying to understand a phenomenon observed in a handful of stars over the last 50 years. You think you may have a new insight into its cause. From the literature you know that photographic observations of these stars exist and that they might be important to your investigation.

As the greater part of the world's photographic spectra and visual images are spread among 50 or more collections in as many observatories, how can you make sure you get the plates you need? Finding someone with the equipment and skills to extract the data may prove the most difficult challenge of all. Through disuse, the time is rapidly approaching when no one will be able to read plates.

The International Astronomical Union created a Working Group chaired by Elizabeth Griffin to tackle this problem. By bringing the plates together with the equipment and know-how needed to process them, the potential of the inherited data could be realized.

Griffin envisions a Spectroscopic Virtual Observatory (SVO) — an international center, equipped with the tools for extracting photographic spectra, and to which plates would be transported in sequence for processing by a small, permanent staff. Once the material is digitized, the information held there would be available as a web-based resource to the entire astronomical community. The Herzberg Institute of Astrophysics (HIA) in British Columbia, has agreed to house SVO at Victoria's Dominion Astrophysical Observatory, provided Griffin can identify funding sources during 2001.

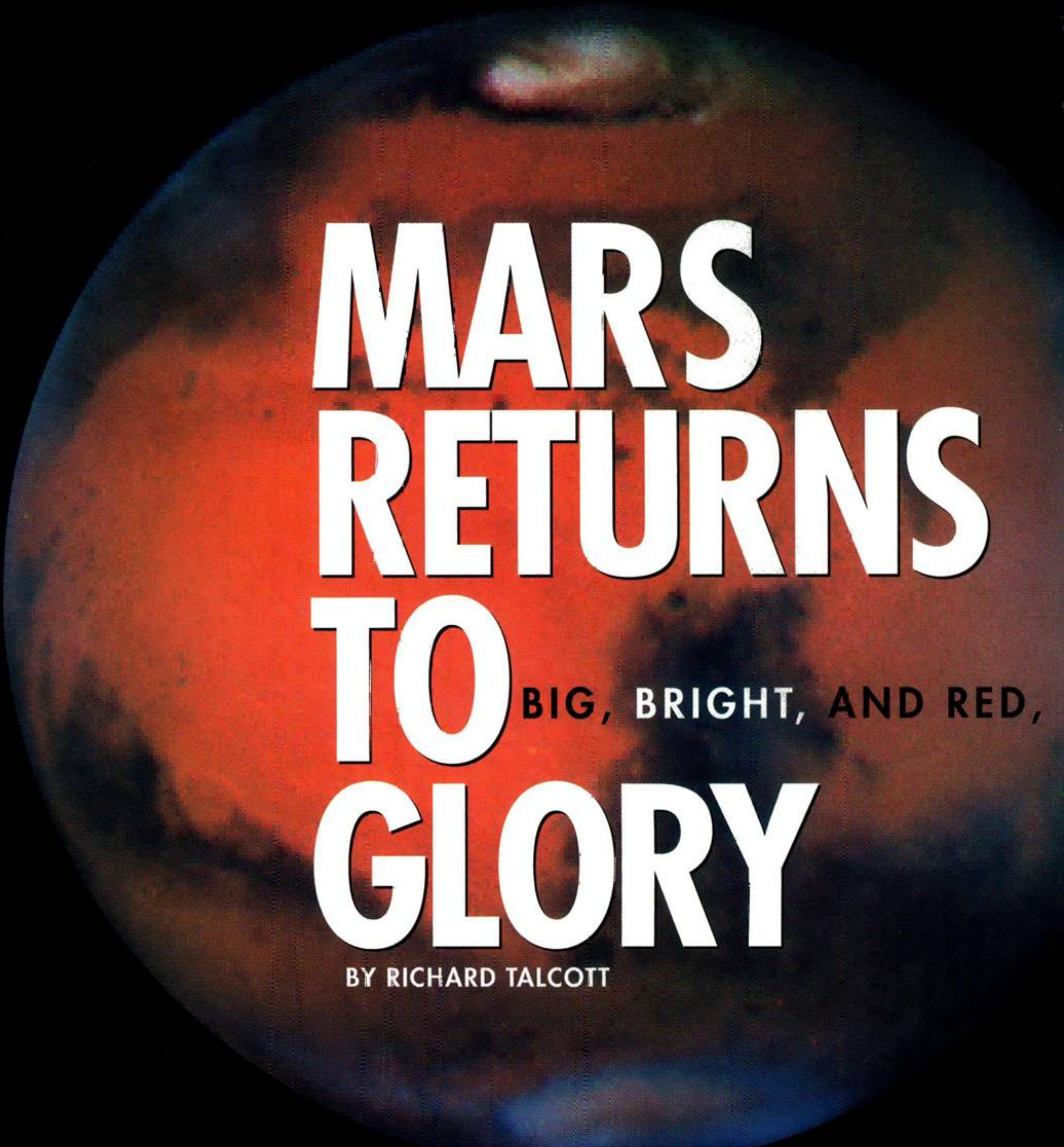
Processing millions of plates in the world's collections is neither practical nor desirable, but not all hold equal interest. Time-varying phenomena are probably the best candidates for digitizing. High-dispersion plates would probably be given preference because they contain the most detailed information and are the least likely to have been exhaustively studied. The plates meeting those criteria number in the tens of thousands — three to five years' work for a pair of dedicated digitizing machines.

Photographic spectra lend themselves to relatively efficient processing. The product of the extraction, in most cases, is a simple string of numbers representing wavelength and intensity — easily stored, manipulated, and displayed to suit the researchers' purposes.

Photographic images have much in common with photographic spectra, but while the two are often scientifically complementary, they require fundamentally different processing activities. Visual plates are larger than spectrograms, and scanning them takes much longer. Where high-dispersion spectrograms can typically be processed at the rate of three or four an hour, a single photographic plate might require three or four hours to scan. Their size and weight present additional problems of transport and storage that are less significant in the case of smaller spectrograms. The IAU Working Group was charged with developing a strategy and efforts are underway to safeguard photographic spectra. A parallel program has also been launched at the Royal Observatory, Brussels, to handle the digitization of direct plates stored in Europe.

In addition, archives of both ground- and space-based observations are beginning to appear in the public domain. Public electronic data archives are a component in the planning of every major new telescope. The means exist to place the most important of the world's inherited photographic observations into a modern archive where they will contribute an essential fourth dimension (time) for research as well as create a new, unique resource for education. Astrophysics will be the ultimate loser if we allow this element of astronomy's inheritance to slip irretrievably into oblivion, while the opportunity to revitalize it lies within our grasp.

**Anthony Misch studies photographic plates at Lick Observatory.** Nina Misch



# MARS RETURNS TO GLORY

BIG, BRIGHT, AND RED,

BY RICHARD TALCOTT

NASA/STScI

Perhaps no planet fascinates us as much as Mars. A century ago, hopeful people saw canals crisscrossing the Red Planet, delivering water to a dying civilization; those of a different bent were drawn to the fanciful tale of marauding armies depicted in *The War of the Worlds*. Today, cutting-edge science suggests that water once flowed across the planet's surface, and life, just possibly, might have gained a foothold.

Yet Mars's ability to intrigue both scientists and the general public owes precious little to its typical appearance in our sky. Most of the time, the planet appears as nothing more than a modestly bright, ruddy point of light. But every two years or so, it brightens dramatically and dominates the night sky, becoming a visual "star" to match or even exceed its cultural and scientific celebrity.

# MARS REACHES A DRAMATIC PEAK THIS SUMMER.

That time is now upon us. The summer of 2001 will see Mars shine brighter and appear larger than it has since 1988. The peak of the apparition occurs in mid-June, when Mars lies opposite the sun in the sky and remains visible all night long. This alignment, called opposition, also marks the peak in the planet's brightness.

This year it appears brighter than any object in the sky except the sun, moon, and Venus, which currently blazes in the east before dawn. The best views through a telescope also come around opposition, when Mars lies close to Earth and thus appears large.

Not all oppositions of Mars are created equal, however. More than any other planet, Mars at opposition can range from truly spectacular to downright mediocre. Fortunately for Earthbound observers, the view this year tips decidedly toward the former.

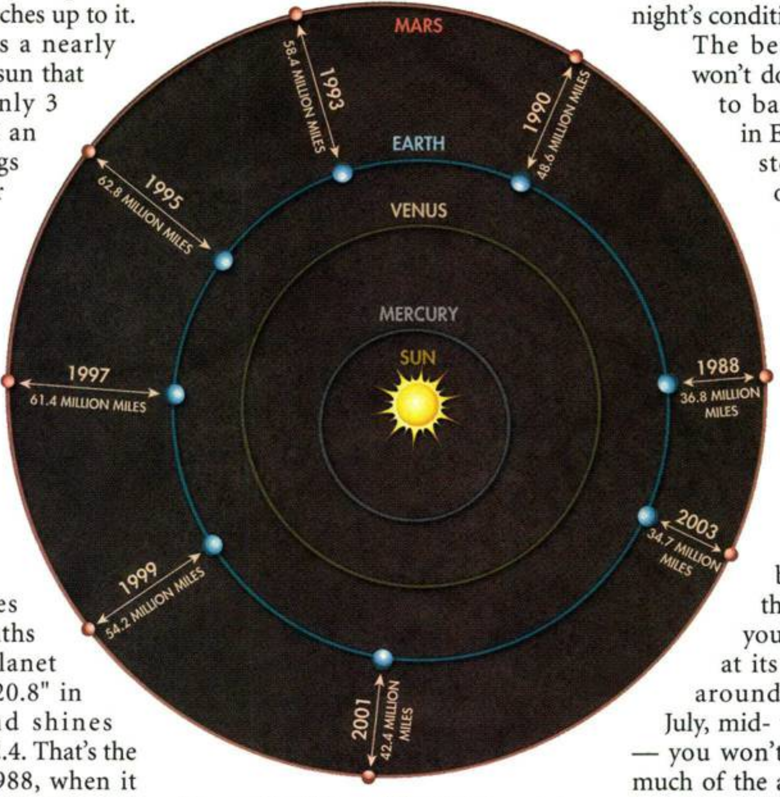
The quality of any Mars apparition depends largely on where the planet lies in its orbit as Earth catches up to it. Unlike Earth, which has a nearly circular orbit around the sun that varies in distance by only 3 million miles, Mars has an eccentric orbit that brings it 27 million miles closer to the sun at closest approach than when it is farthest away. If opposition occurs when Mars lies near its closest point to the sun, or perihelion, it appears bright and large. If opposition occurs when Mars roams far away from the sun, at aphelion, it looks relatively small and faint.

In 2001 Mars reaches perihelion just four months after opposition. The planet swells to an impressive 20.8" in apparent diameter and shines brilliantly at magnitude –2.4. That's the best it has done since 1988, when it grew to 23.8" across and shone at magnitude –2.8.

The only significant drawback to this year's apparition arises from Mars's position deep in the southern sky. Traversing the southern reaches of the constellation Ophiuchus, between the more-recognizable shapes of Scorpius and Sagittarius, the planet never gains a lot of altitude for observers at mid-northern latitudes. Still, it's so big and bright that it appears markedly better than at other recent apparitions. (And if you live in the Southern Hemisphere, where Mars passes nearly overhead, this apparition excels.)

The southerly position does offer one nice perk, however. Mars currently lies near its ancient nemesis, the 1st-magnitude star Antares in Scorpius. The name Antares derives from Greek words meaning "rival of Ares" (Ares being the Greek equivalent of the Roman god Mars). The reference applies only to their similar colors — ruddy Antares can't compete with Mars in the brightness arena this year.

Although Mars has been bright since spring, it's only now coming into prominence. That's because it rises early enough for evening observers to get a good view. From now through the middle of October, the planet remains brighter than magnitude 0 and appears larger than 10" in diameter. Ten arcseconds marks the threshold at which modest backyard telescopes begin to reveal many of the famous surface features visible on Mars.



**At opposition this year, Mars lies closer and looms larger than at any time since 1988.**

*Astronomy*: Elisabeth Rowan

## Getting the Best View

You can get sharp views of Mars with almost any good 3- or 4-inch telescope and a set of high-quality eyepieces. Most veteran planetary observers usually favor refractors over reflectors because they provide the highest image contrast. The next best choice would be a long-focus Newtonian or Cassegrain reflector.

To find the best magnification for the Red Planet on a given night, start with a low-power eyepiece and then increase the magnification to roughly 20 to 25 times the telescope's aperture in inches. (For example, shoot for about 160x if you use an 8-inch telescope.) This should give you a crisp view with enough magnification to see plenty of detail. Continue trying successively higher-power eyepieces until increasing the magnification shows no more detail. Back off to the previous eyepiece and you should have an aesthetically pleasing view with as much detail as your telescope and the night's conditions allow.

The best optics in the world won't do much good if you have to battle a lot of turbulence in Earth's atmosphere. A nice steady atmosphere, what observers commonly refer to as "good seeing," is just as important for getting sharp views — particularly this year when Mars rides low in the southern sky and its light thus has to pass through more air than normal.

Although you might think that the state of the atmosphere lies well beyond your control, that's only partially true. If you observe Mars when it's at its highest in the south — around midnight in June and July, mid- to late evening in August — you won't be looking through as much of the atmosphere. You can also improve the local seeing significantly by choosing an observing site in an open grassy area or looking over a large body of water. Avoid obvious heat sources, such as concrete buildings and asphalt parking lots, that soak up the sun's heat during the day and release it at night. Letting your telescope cool down to the ambient air temperature for 30 to 60 minutes before observing will also help.

Finally, experienced Mars observers swear by a good set of color filters. An orange (Wratten #21 or #23A) filter or a red (#25 or #29) filter works best for showing the ubiquitous dark surface markings. These filters brighten the orange-red deserts and darken the markings, enhancing contrast in the process. Green (#56, #57, and #58) and

# FOLLOWING THE MARTIAN SUN

Monuments like Stonehenge show that early humans tracked the sun's position in the sky. Knowing the sun's habits helped make agriculture a workable proposition and would have eased an otherwise severe life. It certainly makes sense to think that when humans visit Mars and attempt to survive in that planet's harsh climate, the sun will play an equally important role.

We wanted to learn how the sun's position would change in the martian sky. One technique would be to snap the sun's picture at the same time of day at equal intervals through the year. On Earth, such a multiple-exposure photo traces a figure-eight pattern in the sky (lower right). The analemma, as it is called, graphically shows the difference between apparent solar time, what a sundial would show, and mean solar time, which moves at a uniform rate all year. The difference arises because Earth follows an elliptical orbit, so its speed varies, and Earth's axis tilts with respect to its orbit.

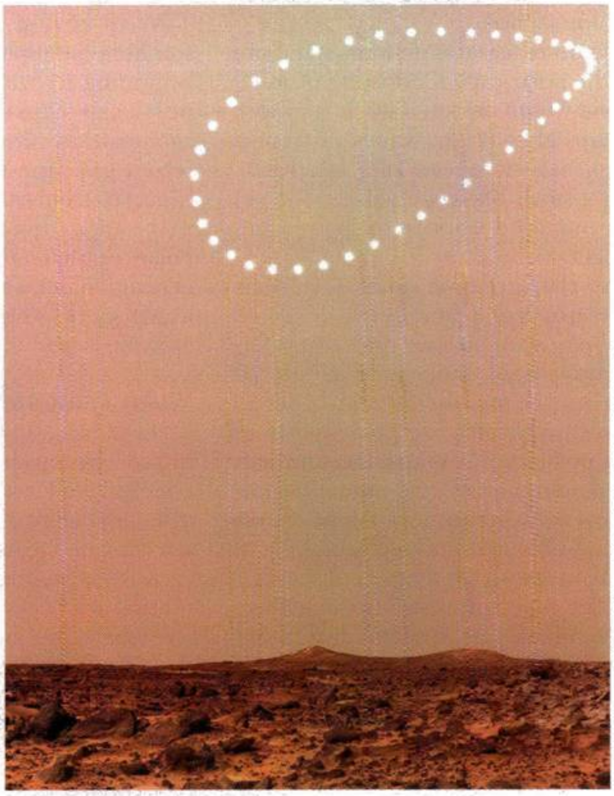
To see what a martian analemma might look like, we simulated the view above the western horizon of the Mars Pathfinder landing site (right). In the image, due west lies just right of the two hills dubbed the Twin Peaks. We determined this from an image of the landing site taken by the Mars Global Surveyor spacecraft and processed by Tom Duxbury and Tim Parker of JPL. The angular separation of the peaks turned out to be 16.8°, which set the scale for the ground image. We then used the latitude of the landing site to set the orientation of the celestial equator with respect to the horizon.

The original Pathfinder image didn't stretch high enough to include the full analemma, so we extended it vertically about 60° with image-processing software. We tried to match the color and shade of the simulated sky with the natural sky captured by Pathfinder, but made it brighter toward the top because sunlight would pass through less airborne dust at greater elevations.

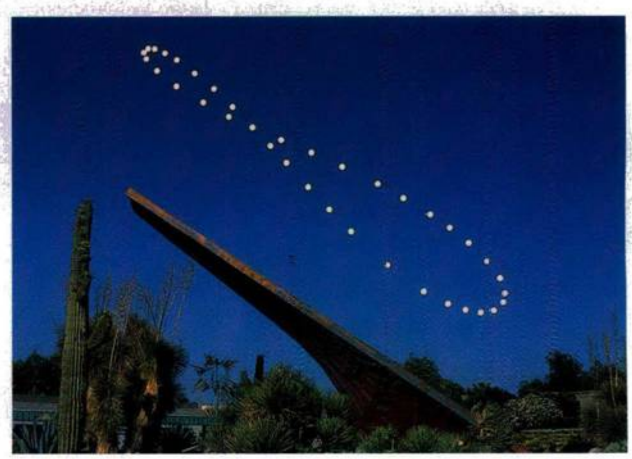
The analemma is centered on the celestial equator and extends 25° to either side, matching the tilt of the planet's spin axis to the plane of its orbit around the sun. We then inserted images of the sun using image-processing software. To make the images clearer, we "overexposed" them to a diameter of about 1°, approximately three times larger than the sun would actually appear on Mars and twice as big as the sun appears from Earth. We reduced the sun's size slightly near the summertime tip of the analemma (at upper right) to account for the sun's greater distance at that time.

To produce the analemma, we calculated the difference between apparent solar time and mean solar time on Mars and then converted it to sky degrees using the planet's spin rate. The resulting analemma consists of 46 separate sun images staggered evenly in time about every 15 days. The images overlap near the summertime tip because the sun moves slowly and its declination changes little around the summer solstice.

Although the height and orientation of the analemma to the horizon suggest that such an image could be made only in the late afternoon of the martian day, you might notice that the position of the sun doesn't match with the shadows cast by the rocks on the ground. The unedited Pathfinder photo was taken closer to midday on Mars, when the sun was far to the south (left) of the field of view. — *Darren M. Williams and Steve Szklenski*



Darren M. Williams and Steve Szklenski (Penn State Erie) and NASA/JPL



Frank Zullo

blue (#38, #38A, or #80A) filters will emphasize the polar caps and bring out any fog, haze, or clouds in the planet's thin atmosphere.

No other features on Mars stand out like the polar caps. Consisting of water ice and frozen carbon dioxide (dry ice), the caps glow bright white and appear conspicuous whenever they face Earth. Even a small telescope will let you see them wax and wane with the planet's changing seasons.

For the first time since 1993, Mars presents an equatorial view to observers at opposition this year. (The past three oppositions have all favored viewing the northern hemisphere.) That should provide good views of both polar caps, though the southern cap should appear much more prominent. That's because mid-June marks the end of winter and the beginning of spring in Mars's southern hemisphere.

Mars experiences seasons much like those on Earth because its axis tilts 25° to the plane of its orbit around the sun, just 2° more than the tilt of Earth's axis. The only major differences: Martian seasons last nearly twice as long as those on Earth because the planet's year equals nearly two Earth years, and seasons in the southern hemisphere of Mars are more severe because the planet always lies farther from the sun when it's winter in the south and closer to the sun when it's summer.

With spring just starting in the southern hemisphere, the sun's rays are beginning to beat down on the south polar cap, causing the ices there to sublimate, or turn directly from a solid into a gas. In a telescope's eyepiece, expect to see the south polar cap shrink as the apparition progresses. The north polar region, on the other hand, will be getting colder and darker as the sun heads south, so that polar cap will be growing larger.

## An Atmosphere in Motion

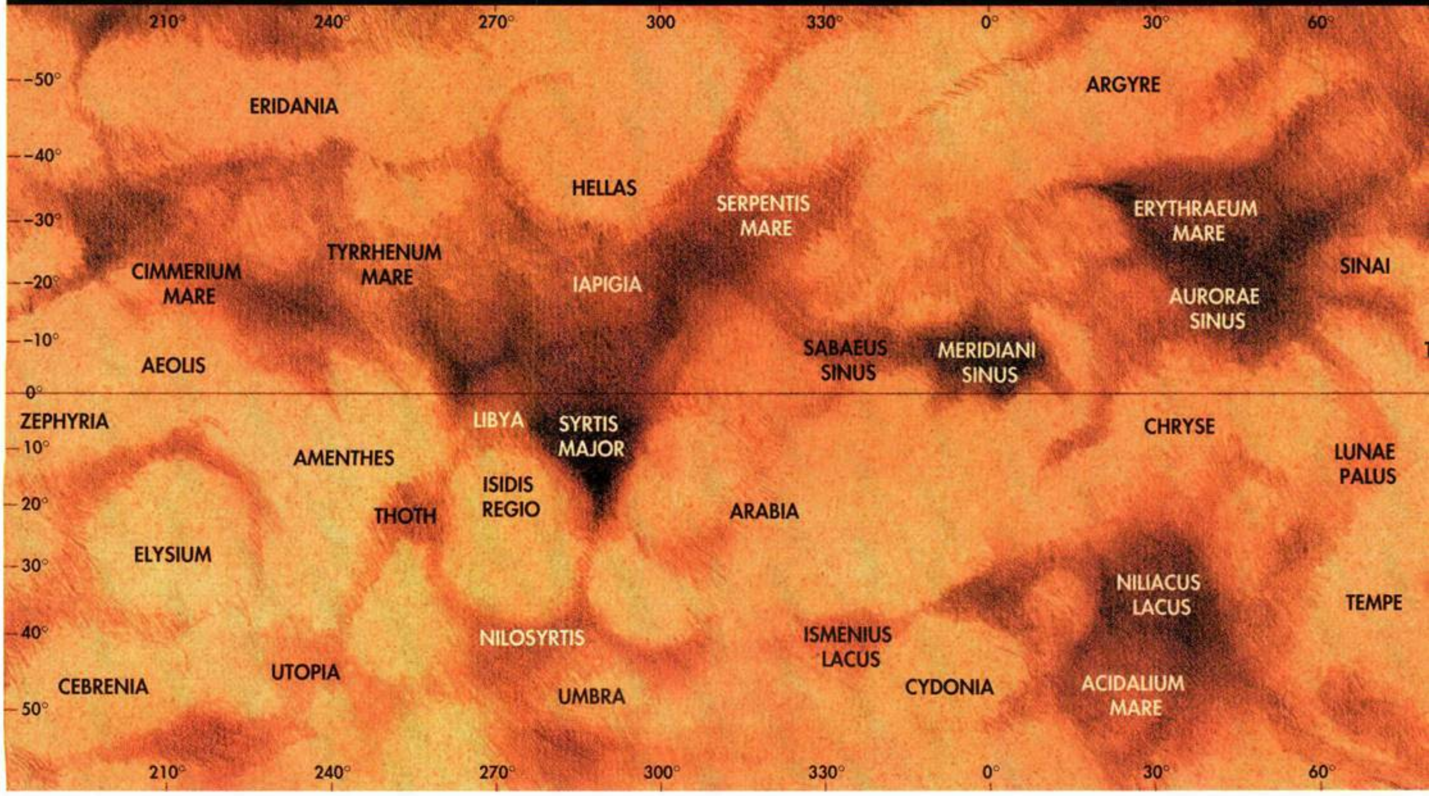
As the ice caps sublimate, they help drive the surprisingly dynamic atmosphere. Even though its density is just 1 percent of Earth's, the martian atmosphere creates a variety of hazes, clouds, fogs, and frosts that can be spotted in a backyard telescope.

Perhaps the most intriguing clouds are orographic clouds, which form when moist air cools as it rises over high mountains. Composed of water-ice crystals, these clouds appear white. They are seen most often around the huge volcanoes of the Tharsis Ridge — Olympus Mons, Ascraeus Mons, Pavonis Mons, and Arsia Mons. Don't expect to see the volcanoes themselves — they are extraordinarily difficult to spot even under the best conditions — but catching a glimpse of these orographic clouds at least lets you see their effect on the weather.

The most dramatic weather phenomenon you might see on Mars is a dust storm. No one knows when a dust storm might hit or how severe it will be, but the worst of these storms can obliterate the entire planet under a blanket of yellow dust. Fortunately, dust storms usually occur around or shortly after Mars reaches perihelion, so the odds seem good that the planet will remain clear during the best observing window. Dust storms usually start as an unusual brightening that encroaches on neighboring dark features. Keep a particularly close eye on the Hellas Basin, the Serpentis region northwest of Hellas, and the Solis Lacus region, where many previous dust storms originated.

To spot the changing features of Mars — the clouds, frost patterns, incipient dust storms, and the like — you need to know the features that don't change or that change only slowly. The map below shows those features within about 60° latitude of the martian equator. Learn these dark,

FEATURES OF THE MARTIAN SURFACE


210°
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-50°
-40°
-30°
-20°
-10°
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10°
20°
30°
40°
50°
ERIDANIA
ARGYRE
HELLAS
SERPENTIS MARE
ERYTHRAEUM MARE
TYRRHENUM MARE
CIMMERIUM MARE
IAPIGIA
AURORAE SINUS
SINAI
AEOLIS
SABAEUS SINUS
MERIDIANI SINUS
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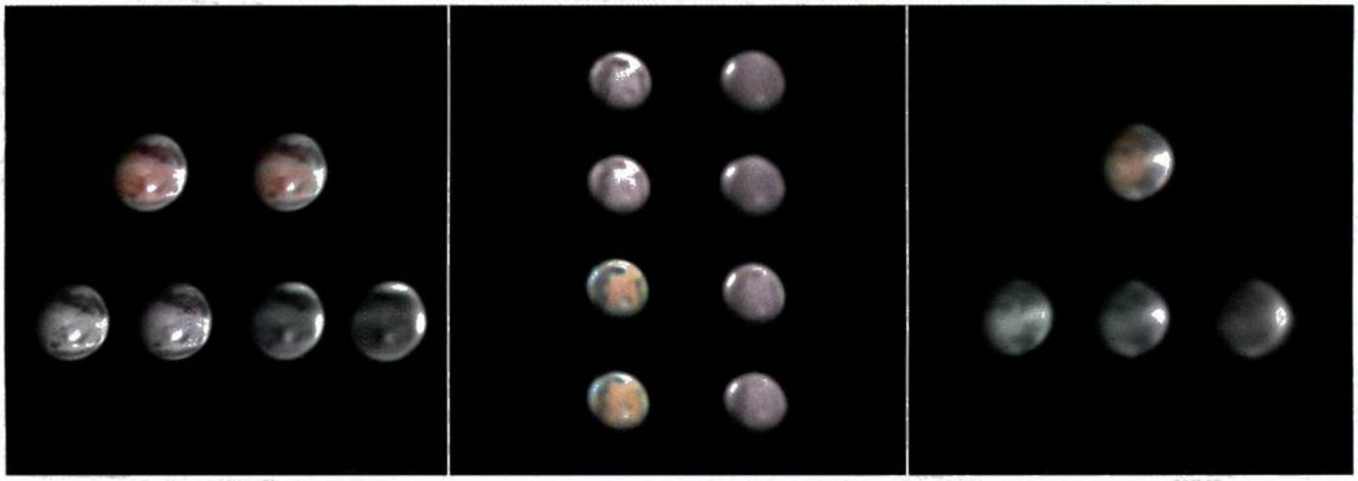
*Astronomy*: Elisabeth Rowan



**Dark markings stand out against the ocher hue of the rest of Mars in these images taken early during the current apparition.**

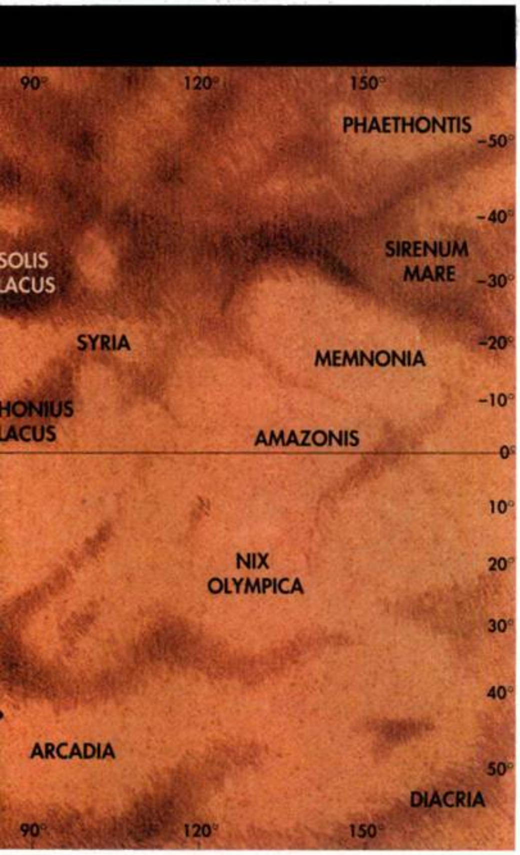
Donald Parker

static features and use them as a guide to locate the changing features in the months ahead.

Knowing what region of Mars you're looking at is the key to learning the reference features. Mars rotates once every 24 hours and 37 minutes, so one "day" on Mars lasts slightly longer than one Earth day. If you observe at the same time on consecutive nights, Mars has only rotated through about 350° of longitude, and you will see the same features a little farther to the east. Thirty-seven minutes later, the features return to the same orientation as on the previous night.

With the table below, you can determine the central meridian of Mars — the line of longitude that bisects the visible hemisphere — at any time on any night during the next several months. Once you know the central meridian at the time of your planned observation, use the map to find which of the bright and dark features will be most prominent.

Once the current apparition winds down late this year, many Mars observers will simply feel like their appetites have been whetted. That's not necessarily a bad thing, because the next apparition will prove to be even better. The opposition awaiting us in August 2003 will provide the best views of Mars in our lifetime, with perihelion arriving just two days after opposition. The Red Planet will then appear bigger and brighter than it has at any time in more than 1,000 years — measuring a healthy 25.1" across and gleaming at magnitude –2.9 — and be reasonably high in the sky to boot. It's an opportunity no skygazer will want to pass up. ■



## MARTIAN CENTRAL MERIDIANS

| Date | Central Meridian |
|---|---|
| June 1 | 321° |
| June 6 | 276° |
| June 11 | 232° |
| June 16 | 187° |
| June 21 | 143° |
| June 26 | 99° |
| July 1 | 54° |
| July 6 | 9° |
| July 11 | 325° |
| July 16 | 279° |
| July 21 | 234° |
| July 26 | 188° |
| July 31 | 142° |
| August 5 | 96° |
| August 10 | 49° |
| August 15 | 2° |
| August 20 | 315° |
| August 25 | 268° |
| August 30 | 221° |
| September 4 | 173° |
| September 9 | 125° |
| September 14 | 78° |
| September 19 | 30° |
| September 24 | 342° |
| September 29 | 293° |

To find surface markings on Mars, locate the feature on the albedo map (left) and then determine when it will lie at the center of the martian disk using this table. It gives the central meridian at 11 P.M EDT (10 P.M. CDT, 9 P.M MDT, 8 P.M PDT) during the summer months. To find the central meridian at other dates and times, subtract 9.1° for each day after a tabulated date and add 14.6° for each hour after a tabulated time.

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| 32mm 2" | 239.95 | | |

**PLOSSL SERIES 4000 ULTRA WIDE ANGLE**

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|---|---|---|---|
| 4.7mm 1.25" | 169.95 | 8.8mm 1.25"/2" | 239.95 |
| 6.7mm 1.25" | 199.95 | 14mm 1.25"/2" | 299.95 |

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| MA 12mm Astrometric 1.25" | | 119.95 |
| Plossl 25mm CCD Framing Ocular 1.25" | | 129.95 |

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| **#122** 2x Telenegative 1.25" | 44.95 |
| **#126** 2x Short Focus 1.25" | 44.95 |
| **#127** 2x-3x Variable 1.25" | 56.95 |
| **#134** Achromatic .96" | 44.95 |
| **#140** 2x Apochromatic 1.25" | 74.95 |

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| **LXD 300 SERIES 203** 8" f/10 | $795 |
| **LXD 500 SERIES 203** 8" f/10 | $895 |
| **LX-200 8"** | $2,295 |
| **LX-200 10"** | $2,695 |
| **LX-200 12"** | $3,995 |
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| **Magellan I #2014** f/LX-10 | 375 |
| **Magellan II #2024** f/LX-50 | 495 |

### ED APO REFRACTORS

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|---|---|
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| | |
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| **102 Apochromatic** 4" f/9 | $1,649 |
| **102 Achromatic** 4" f/9 | $695 |
| **102ED 4"** f/9 w/Mount, Tripod & Acc. | $2,795 |
| **127ED 5"** f/9 w/Mount, Tripod & Acc. | $3,295 |
| **152ED 6"** f/9 w/Mount, Tripod & Acc. | $4,995 |
| **178ED 7"** f/9 w/Mount, Tripod & Acc. | $5,995 |

| | |
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| Optical Tube Only | CALL |
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| **#1664** Electronic Drive | 349 |
| **#1697** Computer Drive System | 749 |
| **#1702** Dual Axis Drive System | 195 |
| **#1812** Electronic DC Adapter | 89.95 |

## ACCESSORIES

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| **#62** T-Adapter f/SCT | 26.95 | Off Axis Guider | 79.95 |
| **#931** 45° Hybrid Erct Prsm | 43 | f/6.3 Focal Reducer | 129.95 |
| Basic Tele-Extender | 29.95 | **#1205** Focuser | CALL |
| Camera Adapter 1.25" | 29.95 | **#1206** Focuser | CALL |
| Camera Adapter .96" | 27.95 | 6x30 Viewfinder | CALL |
| Variable Tele-Extender | 39.95 | 8x50 Viewfinder | CALL |
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| Piggyback Bracket f/SCT | Call | 55 Manual DEC Control | 75 |

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| Variable Projection Camera Adapter 1.25" | 39.95 |
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| **#531** Motor Drive w/Auto Tracking f/4500 Newtonian | CALL |
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| **EPOCH 2000sk** Sky Software 3.5" Disks | 149 |
| **EPOCH 2000sk** Sky Software CD | 179 |
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| **Magellan I #2010** f/Dobsonians | 295 |
| **Magellan I #2011** f/Equatorial 6", 8", 10" | 295 |
| **Magellan I #2012** f/Equatorial 16" | 295 |
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| **DS-70** 70mm (2.8"), 700mm f/10 | $249 |
| **DS-80EC** 80mm (3.1"), 900mm f/11.3 | $449 |
| **DS-90EC** 90mm (3.5"), 1000mm f/11.1 | $499 |

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| **DS-114EC** 114mm (4.5"), 910mm f/8 | $399 |
| **DS-127EC** 127mm (5"), 1020mm f/8 | $499 |
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| 10x42 Safari Pro | 190 | 10x50 WA Safari Pro | 200 |
| 7x42 WA Rainforest Pro | 480 | 8x56 Rainforest Pro | 500 |

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Package includes: Scope, 20-60x, Case & Tripod.

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With the touch of a button, the NexStar 8 will open door to planets, galaxies and nebulae that you have never experienced in your lifetime. Exquisite design, pinpoint computer control and stability come together in one dynamic package.

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| **NexStar 8** 8", 2032mm f/10 | $1,899 |
| **NexStar 5** 5", 1250mm f/10 | $1,199 |
| **NexStar 60 ST** ***NEW!*** | $189 |
| **NexStar 60 GT** ***NEW!*** | $299 |
| **NexStar 80 HC** ***NEW!*** | $299 |
| **NexStar 80 GT** ***NEW!*** | $399 |
| NexStar Tripod | $175 |
| **G-3** 3.5", 1000mm f/11 | $499 |
| **G-5** 5", 1250mm f/10 | $699 |
| **G-8** 8", 2032mm f/10 | $999 |
| **G-9 1/4** 9-1/4", 2350mm f/10 | $1,299 |
| **CM-1100** 11", 2800mm f/10 | $3,199 |

### REFRACTORS

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80mm (3.1")
*3 Models Avail.*

**Firstscope 70 Series**
70mm (2.8")
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**Firstscope 60 Series**
60mm (2.4")
*4 Models Avail.*

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| **Firstscope 60 Equatorial** | $159 |
| **Firstscope 80 Equatorial** | $349 |

| | |
|---|---|
| **C80-HD** 80mm (3.1"), 900mm f/11 | $349 |
| **C102-AZ** 102mm (4"), 1000mm f/10 | $329 |
| **C102-HD** 102mm (4"), 1000mm f/10 | $499 |
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| 4.5" | $239 | 6" | $399 | 8" | $499 |

### EYEPIECES & VIEWING ACCESSORIES

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| Diagonal, Erect Image 45° | | | 39.95 |
| Diagonal, Erect Image 90° | | | 49.95 |
| Plossl 1.25" 32, 40mm | 49.95 | Tele-Extender Dlx | 48.95 |
| Plossl 1.25" 6.3, 7.5, 10, 12.5, 17, 20, 26mm | | | 39.95 |
| Ultima 1.25" 5, 7.5, 12.5, 18mm | | | 74.95 |
| Ultima 1.25" 24, 30, 42mm | | | 94.95 |
| Ultima 1.25" 35 | | | 99.95 |
| LV Series 1.25" 5, 6, 9, 10, 15mm | | | 94.95 |
| LV Series 1.25" 2.5, 4, 12, 20, 25mm | | | 109.95 |
| LV Series 1.25" 8-24mm Zoom | | | 159.95 |

**BARLOWS**

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|---|---|---|---|
| 2x 1.25" | 39.95 | 2x .96" | 19.95 |
| 2x 1.25 Ultima | 62.95 | 2x .96" Dlx | 44.95 |

### FILTERS

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|---|---|---|---|
| 4 Piece Filter Sets | 49.95 | Skylight Filter | 44.95 |
| Moon Filter 1.25" | 16.95 | Solar Filters | CALL |
| LPR Filter Model A 1.25" | | | 59.95 |
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| Polarizing Filter Set 1.25" | | | 42.95 |

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Engineered for unsurpassed optical performance in an affordable, full featured Schmidt-Cassergrain telescope of large enough aperture to do serious deep-sky observing. This telescope is carefully crafted and manufactured in the USA for dependable quality of the highest caliber. It offers the lowest price ever for a Celestron fork mounted 8" telescope.

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| **CELESTAR 8** Deluxe | $1,699 |
| **CELESTAR 8** DLX Computerized | $2,199 |
| **ULTIMA 2000** 8" 2032mm f/10<br>2032mm f/10 w/Go To System | $2,699 |
| **CM-1400** 14", 3910mm f/11 **(IN STOCK!)** | $5,299 |

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| C5 Spotter | $599 |
| 80mm Wide View | $199 |
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| 60mm Zoom | $69 |
| 30mm Mini Spotter | $49 |

### TRIPODS & MOUNTS

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|---|---|
| Heavy Duty Tripod (93499) | 284.95 |
| Photographic Tripod (93596) | 99.95 |
| Standard 8" Wedge (93656) | 92.95 |
| Heavy Duty Wedge (93655) | 239.95 |
| Upgrade Kit f/93655 | 109.95 |
| Equatorial Mount CG-3 | 144.95 |
| Equatorial Mount CG-5 | 369.95 |
| CI-700 Mount | 1,859.95 |
| Vibration Supression Pads | 39.95 |

### ACCESSORIES

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|---|---|---|---|
| AC Adapter | 18.95 | Lens Shades | CALL |
| Focus Motor | 114.95 | Motor Drives | CALL |
| Car Battery Adapter | 18.95 | T-Adapter f/C90 | 28.50 |
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Finder Scope $36.49

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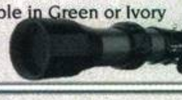

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| w/1.25" 45° Erect Prism (RGA/RIA) | $685 |
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**Ranger Power Package**

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| Includes: 90° Star Diagonal, 20-60x Zoom, 2.5x Powermate & Shoulder Bag (RPP2500) | $1,030 |

### MOUNTS

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| **ZOOM EYEPICE** 8mm-24mm | $210 |

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| **PLOSSL (50°)** | | **PANOPTIC (68°)** | |
| 8, 11mm 1.25" | 82 | 15mm 1.25" | 210 |
| 15mm 1.25" | 82 | 19mm 1.25" | 240 |
| 20, 25mm 1.25" | 95 | 22mm 2"/1.25" | 280 |
| 32mm 1.25" | 110 | 27mm 2" | 330 |
| 40mm 1.25" | 110 | 35mm 2" | 365 |
| 55mm 2" | 228 | Barlow Interface | 90 |
| **RADIAN (60°)** | | **NAGLER (82°)** | |
| 3, 4mm 1.25" | 228 | 4.8mm 1.25" | 175 |
| 5, 6mm 1.25" | 228 | 7mm 1.25" | 220 |
| 8mm 1.25 | 228 | 9mm 2"/1.25" | 240 |
| 10mm 1.25" | 228 | **NAGLER Type 2 (82°)** | |
| 12mm 1.25" | 228 | 16mm 2"/1.25" | 310 |
| 14mm 1.25" | 228 | **NAGLER Type 4 (82°)** | |
| 18mm 1.25" | 228 | 12mm 2"/1.25" | 340 |
| **NAGLER Type 5 (82°)** | | 17mm 2" | 370 |
| 31mm 2" | 595 | 22mm 2" | 445 |

**BARLOWS**

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|---|---|---|---|
| 2x 1.25" | 105 | 2.5x Powermate | 168 |
| 2x Big 2" | 168 | 4x Powermate | 265 |
| 3x 1.25" | 105 | 5x Powermate | 168 |

### ACCESSORIES

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|---|---|
| **RICH FIELD KIT** Includes: 55mm Plossl, 2" Star Diagonal, SCT to 2" E.P. Adptr & 2" to 1.25" E.P. Adptr | 410 |
| **RICH FIELD PREMIUM KIT** w/Everbright 2" Star Diag. | 480 |
| Bino Vue Binocular Viewer | 1,030 |
| Paracorr Photo/Visual 2" Coma Corrector | 259.99 |
| **NEW!** *Everbright 2" Star Diagonal Mirror* | 255 |
| 2" Enhanced Star Diagonal | 190 |
| 1.25" Star Diagonal | 75 |
| 1.25" Prism 45° | 60 |
| Air Chair | 150 |
| Basic Qwik Point (QPU) | 19.95 |
| Starbeam Projection Finder | 180 |
| Camera Adapter 1.25" & 2" | 36 |
| Piggy-Cam Camera Adapter | 42 |

## ASTRONOMY BOOKS

### The Deep Sky: An Introduction

**By Philip S. Harrington** Here is the perfect reference for anyone, who owns a telescope or a pair of binoculars but doesn't know what to look for amid the constellations. It explains how to find double and multiple stars, variable stars, open and gobular clusters, nebulae, and galaxies — what you'll see when you do.Includes 36 full-page sky charts; equipment, books, and software suggestions; sketches of how deep-sky objects look through a small telescope; and more than 100 black & white photographs. 272 pages.

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| The Deep Sky: An Introduction | 24.95 |
| Backyard Astronomer's Guide | 39.95 |
| Nightwatch: A Practical Guide to Viewing the Universe, 3rd Edition | 29.95 |
| Star-Hopping for Backyard Astronomers | 19.95 |
| Celestron Sky Map | 16.95 |
| Meade Star Chart | 16.95 |

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| Deluxe Edition | | | 49.95 |
| Desk Edition | 27.95 | Field Edition | 27.95 |
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| Laminated Desk Edition | | | 59.95 |
| Laminated Field Edition | | | 59.95 |

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| Level IV, Ver. 5 CD f/Windows | $239.95 |

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| **SkyChart III CD** | $38.95 |

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# sky Show

## july

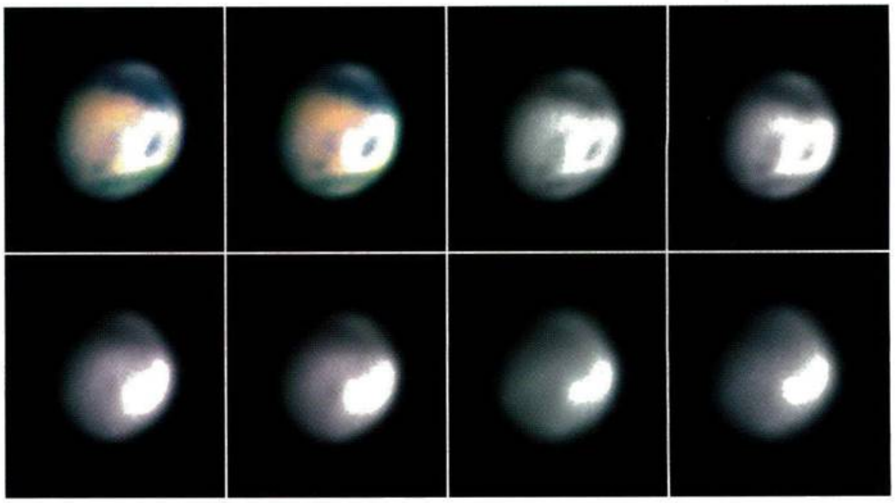
### Mars steals the show and Ceres celebrates 200 years.

by Martin Ratcliffe and Alister Ling

▶ Several planetary matinees are showing this month. It's not often you get a chance to see Venus and Saturn side by side, and during daylight hours on July 15th they pair up in the same eyepiece field. In the following week, the moon crosses in front of four planets. This occultation series starts off with South Americans watching the moon cover up Saturn on the morning of July 17th. The marquee event for North Americans happens a few hours later when Venus succumbs to the moon's bright limb and reappears from behind the nearly invisible side. Indonesians have a chance to see Jupiter occulted mid-morning on the 19th. Not to be outdone, Mercury performs a lunar disappearance on the 19th for global citizens in a strip from northern Europe across the north pole to western Canada.

At night, Mars commands the southern sky, a blazing orange orb nestled in front of the Milky Way. But the triumphant God of War must accept its inevitable downfall that comes from Earth's faster orbital speed. Starting this month Mars begins to noticeably fade and shrink. Observe it as often as you can to get the most from the tapestry of its subtle surface detail. By summer's end, its increasing distance from Earth will challenge your skills to the core.

Notice the phase of the moon when it passes Mars and Antares on the 2nd and 29th. The moon is noticeably less full at the end of the month. The ancients, using the stars as background reference points, recognized that the moon circled Earth in about 27.3 days. The longer lunar month (from one full moon to the next) of 29.5 days is needed for the moon to catch up with the sun-Earth line.



**Mars imaged on March 4, 2001, showing pairs of images centered on central meridians 197° and 199° as color composites (top left), blue light (top right), green light (bottom left), and red light (bottom right).** Donald C. Parker

Finding the gas giant Neptune is easier than you may think. At 8th magnitude, it's within range of 7x50 binoculars and a snap in a 4-inch scope. Just follow the map on page 63.

Will this be your first summer to see the beautiful but elusive noctilucent clouds? Last year, observers in Colorado witnessed a record-breaking display of these wispy, 50-mile-high nighttime clouds. Some scientists consider it a sign of global climate change.

On your next dark summer night, walk away from the campfire to bathe in the glow of our galaxy: the Milky Way. Billions of distant stars shine in unison to produce the celestial river that courses through so many of humanity's mythologies. Discover the many deep-sky treasures — star clusters and nebulae — embedded along its vast shorelines as you slowly peruse it with binoculars.

**The giant open star clusters M7 and M6 are visible to the naked eye.** Douglas C. Zubenel

# July 2001

3 The moon passes 6° north of Mars, 6 A.M. EDT

4 Earth is at aphelion (94.5 million miles from the sun), 10 A.M. EDT

5 Full moon is at 11:04 A.M. EDT; partial lunar eclipse

7 The moon passes 3° south of Neptune, 10 A.M. EDT
Asteroid Ceres is at opposition, 3 P.M. EDT (page 65)

8 The moon passes 3° south of Uranus, 6 P.M. EDT

9 The moon is at apogee (252,007 miles from Earth), 7:23 A.M. EDT
Mercury is at greatest western elongation (21°), 1 P.M. EDT

12 Mercury passes 1.9° south of Jupiter, 6 P.M. EDT

13 Saturn passes 4° north of Aldebaran, 4 A.M. EDT
Last quarter moon is at 2:45 P.M. EDT

14 Venus passes 3° north of Aldebaran, 9 P.M. EDT

15 Venus passes 0.7° south of Saturn, 1 A.M. EDT

17 The moon passes 0.6° south of Saturn, 9 A.M. EDT
The moon passes 0.3° north of Venus, 2 P.M. EDT

18 The moon passes 0.2° south of Jupiter, 8 P.M. EDT

19 The moon passes 1.0° north of Mercury, 9 A.M. EDT
Mars is stationary, 7 P.M. EDT

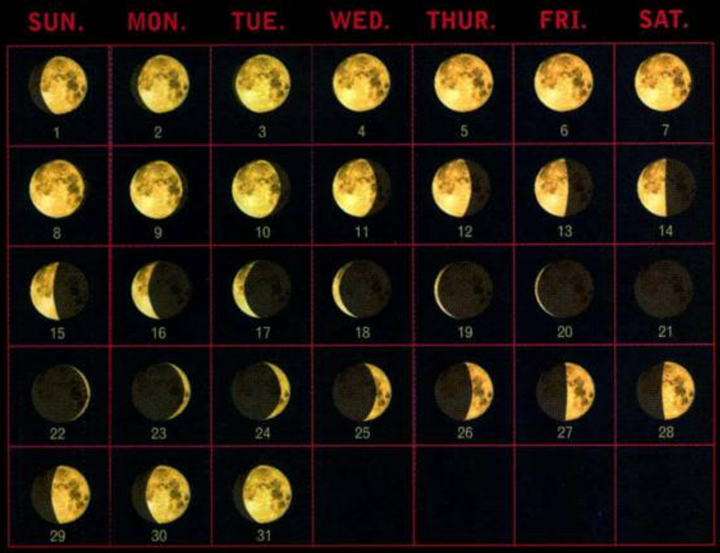
20 New moon is at 3:44 P.M. EDT

21 The moon is at perigee (223,089 miles from Earth), 4:46 P.M. EDT

27 First quarter moon is at 6:08 A.M. EDT
Mercury passes 6° south of Pollux, 11 A.M. EDT

28 Southern Delta Aquarid meteor shower peaks (page 64)

30 Neptune is at opposition, 8 A.M. EDT (page 63)
The moon passes 6° north of Mars, 10 A.M. EDT


SUN.
MON.
TUE.
WED.
THUR.
FRI.
SAT.
1
2
3
4
5
6
7
8
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10
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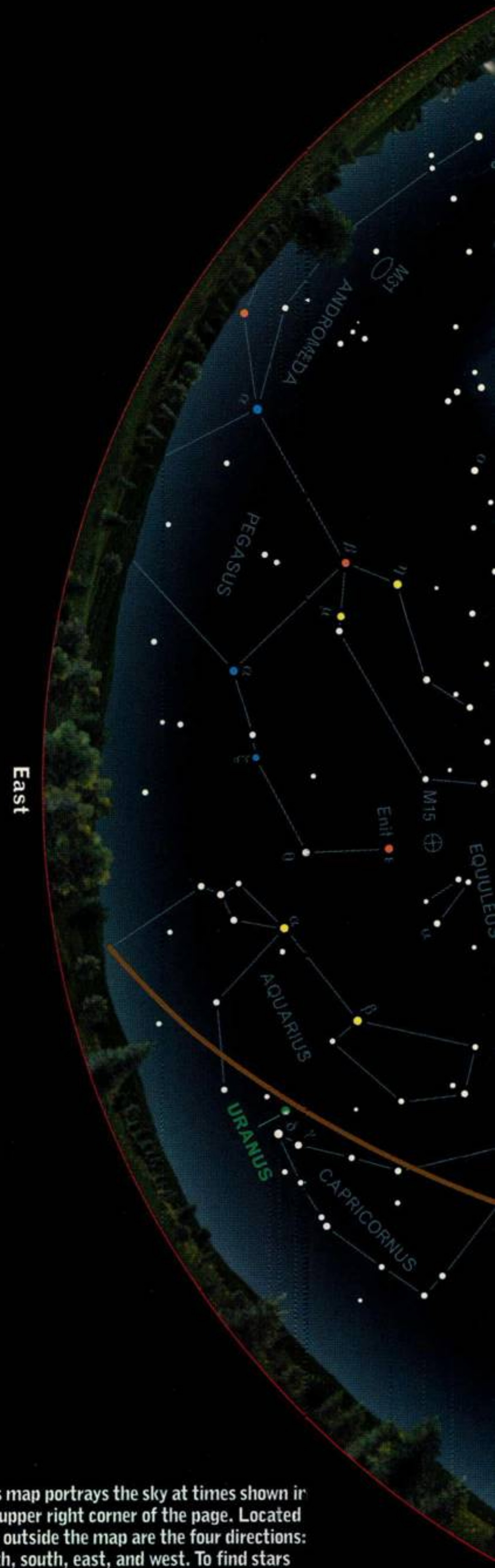
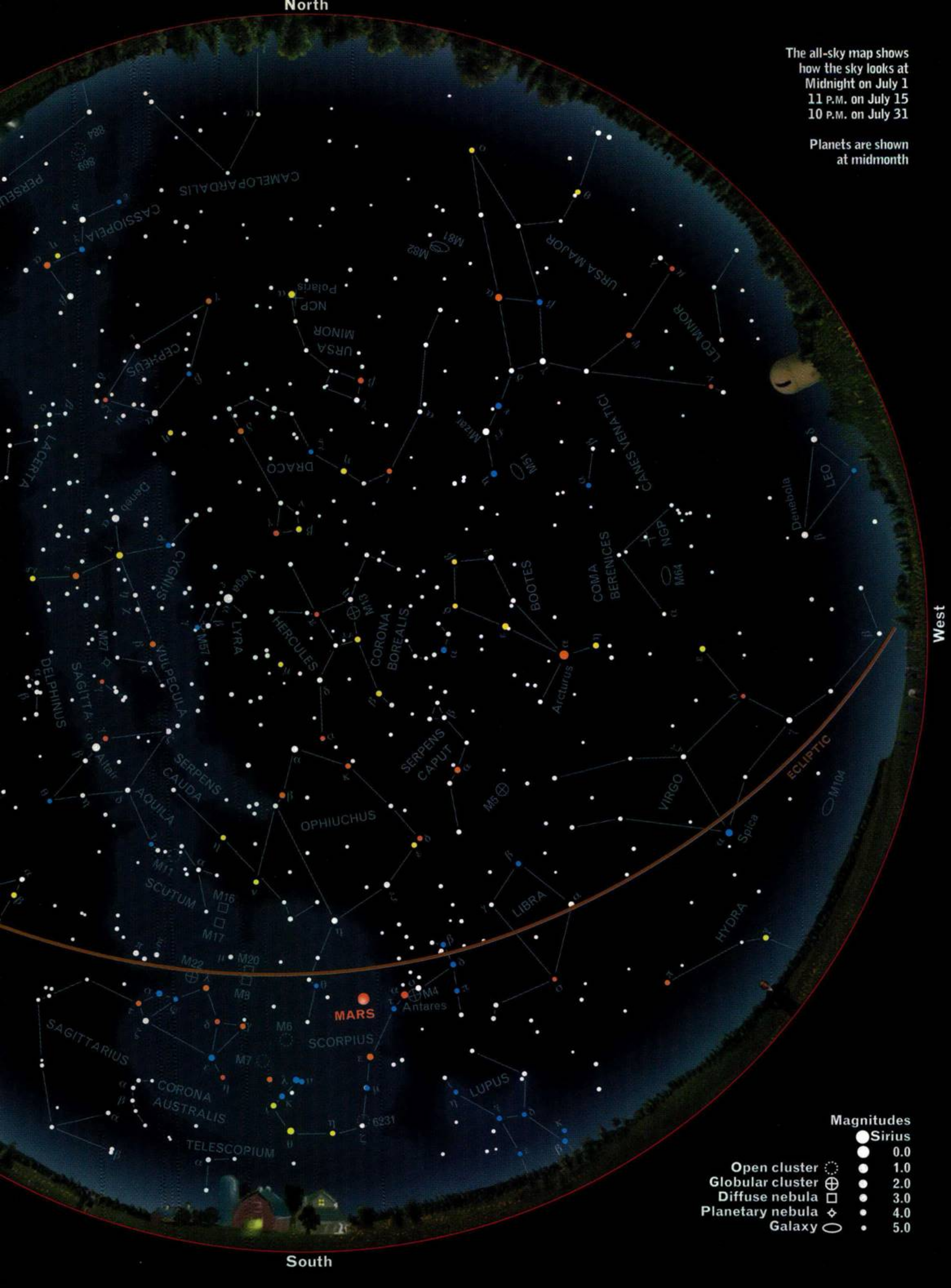
31


East
M31
ANDROMEDA
PEGASUS
M15
Enif
EQUULEUS
AQUARIUS
URANUS
CAPRICORNUS

This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

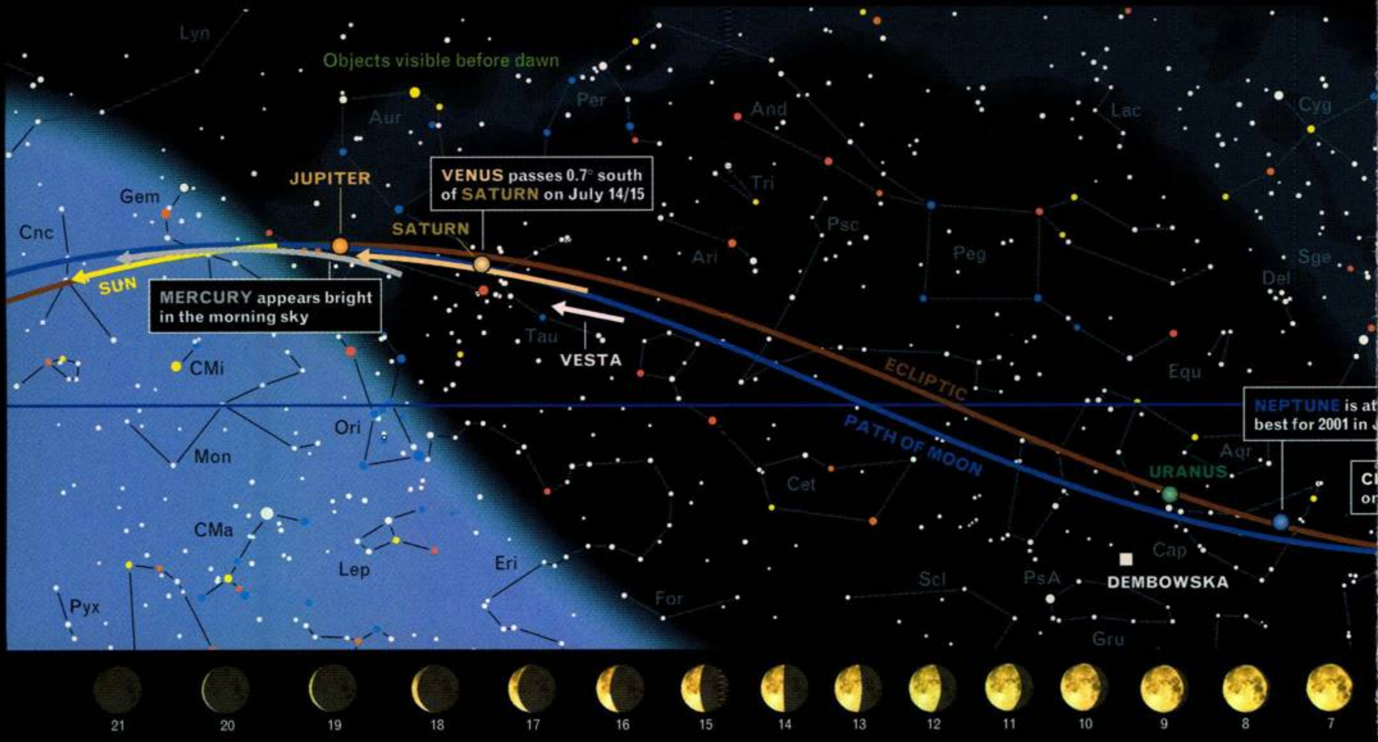

North
South
West
CAMELOPARDALIS
PERSEUS
CASSIOPEIA
869
884
M81
M82
Polaris
NCP
URSA MINOR
URSA MAJOR
LEO MINOR
CEPHEUS
LACERTA
DRACO
Mizar
M51
CANES VENATICI
LEO
Denebola
Deneb
CYGNUS
Vega
LYRA
M57
HERCULES
M13
CORONA BOREALIS
BOOTES
COMA BERENICES
NGP
M64
Arcturus
M27
VULPECULA
SAGITTA
DELPHINUS
Altair
AQUILA
SERPENS CAUDA
OPHIUCHUS
SERPENS CAPUT
M5
VIRGO
ECLIPTIC
M104
Spica
M11
SCUTUM
M16
M17
LIBRA
HYDRA
M22
M20
M8
M4
Antares
MARS
M6
SCORPIUS
SAGITTARIUS
M7
CORONA AUSTRALIS
LUPUS
6231
TELESCOPIUM
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
Midnight on July 1
11 P.M. on July 15
10 P.M. on July 31

Planets are shown
at midmonth

# Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects


Lyn
Objects visible before dawn
Aur
Per
And
Lac
Cyg
Gem
JUPITER
Tri
Cnc
SATURN
Psc
Peg
Sge
Ari
Del
SUN
Tau
VESTA
CMi
ECLIPTIC
Equ
Ori
PATH OF MOON
Aqr
Mon
URANUS
Cet
Cap
CMa
Lep
Eri
Scl
PsA
DEMBOWSKA
For
Pyx
Gru
21
20
19
18
17
16
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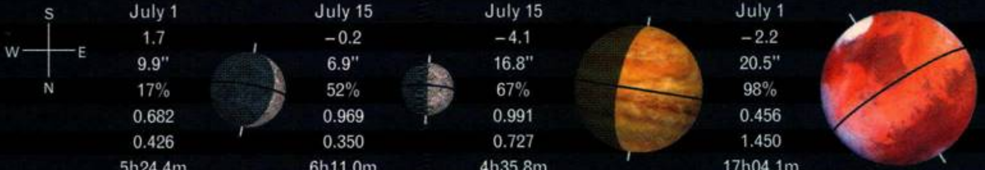
14
13
12
11
10
9
8
7

**VENUS** passes 0.7° south of **SATURN** on July 14/15

**MERCURY** appears bright in the morning sky

**NEPTUNE** is at best for 2001 in

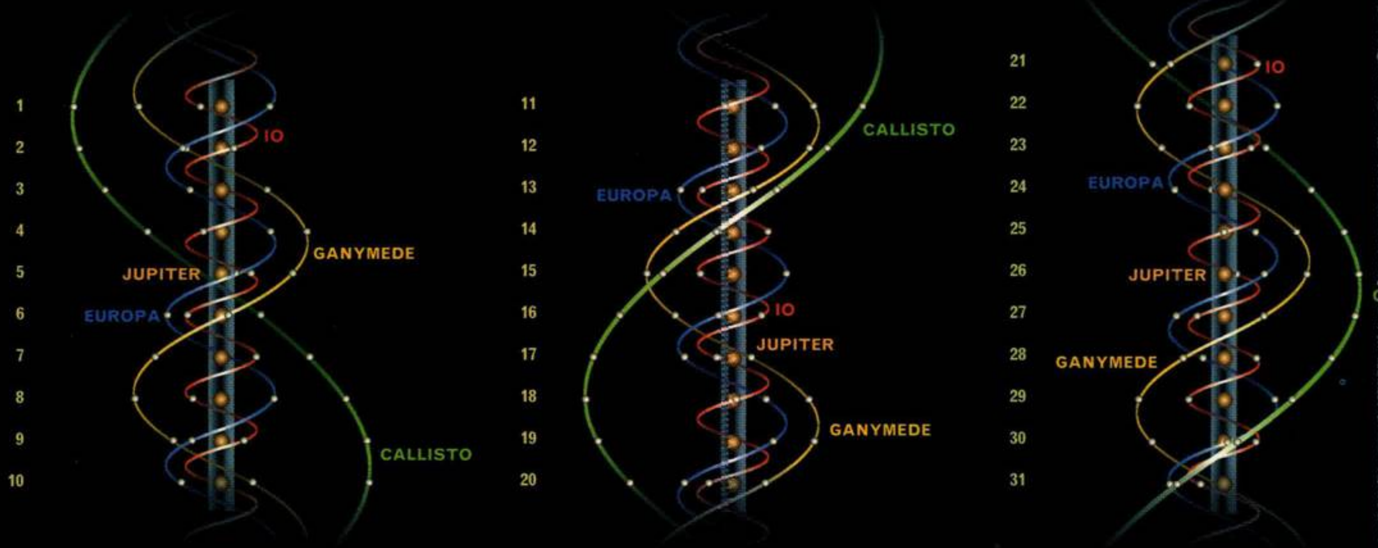
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved



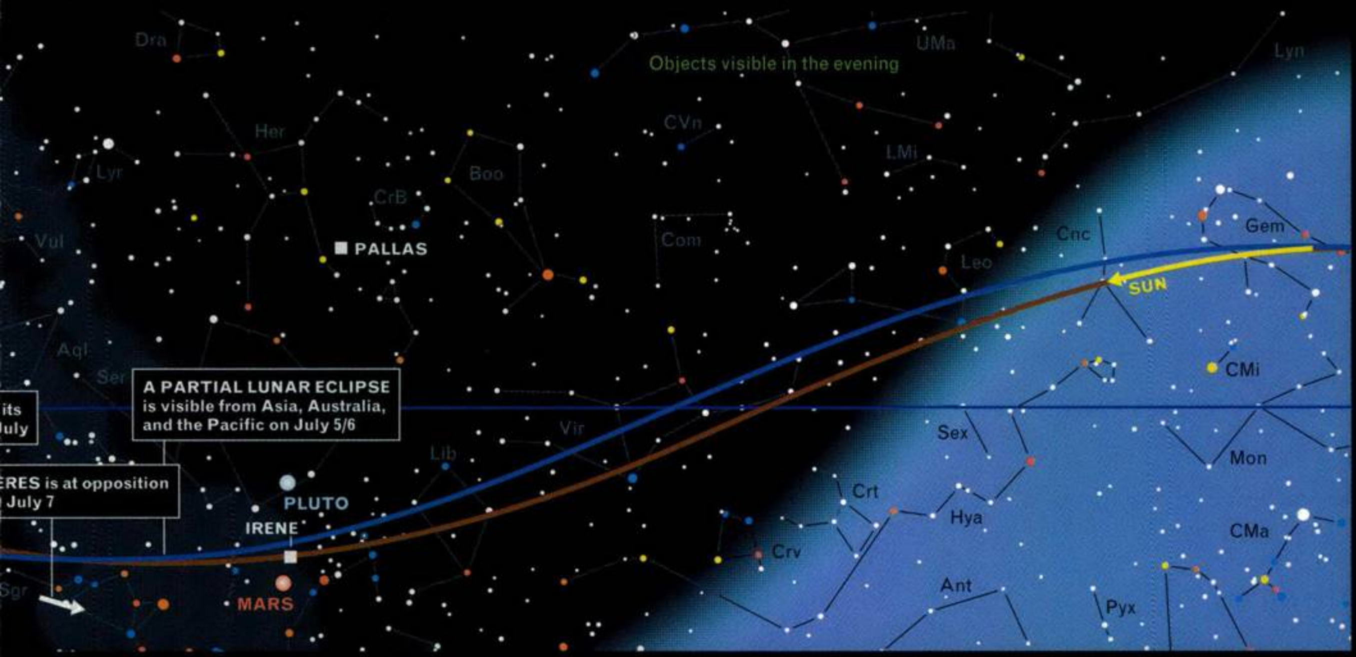
| PLANETS | MERCURY | MERCURY | VENUS | MARS | MARS |
|---|---|---|---|---|---|
| Date | July 1 | July 15 | July 15 | July 1 | July 31 |
| Magnitude | 1.7 | −0.2 | −4.1 | −2.2 | −1.5 |
| Angular Size | 9.9" | 6.9" | 16.8" | 20.5" | 17.2" |
| Illumination | 17% | 52% | 67% | 98% | 91% |
| Distance (AU) from Earth | 0.682 | 0.969 | 0.991 | 0.456 | 0.546 |
| Distance (AU) from Sun | 0.426 | 0.350 | 0.727 | 1.450 | 1.418 |
| Right Ascension (2000.0) | 5h24.4m | 6h11.0m | 4h35.8m | 17h04.1m | 16h56.9m |
| Declination (2000.0) | 18°52' | 21°40' | 19°35' | −26°51' | −26°52' |

# Jupiter's Moons

Dots display positions of Galilean satellites at 5 A.M. EDT on date shown. South is at top to match the view in a telescope.



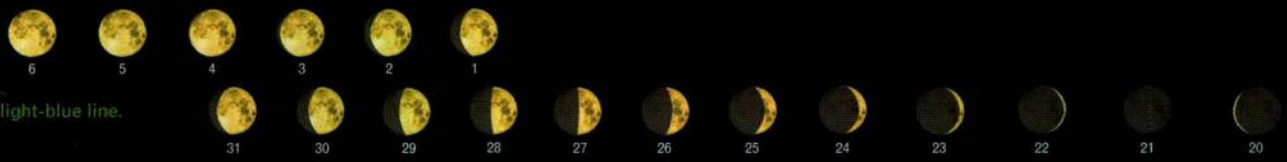
during the month.


Dra
UMa
Lyn
Objects visible in the evening
Her
CVn
LMi
Lyr
Boo
CrB
Vul
PALLAS
Com
Leo
Cnc
Gem
SUN
Aql
Ser
CMi
Vir
Lib
Sex
Mon
PLUTO
IRENE
Crt
Hya
CMa
Sgr
MARS
Crv
Ant
Pyx

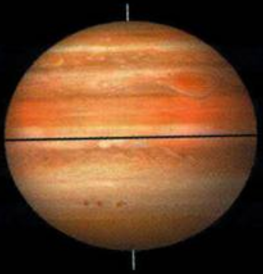
**A PARTIAL LUNAR ECLIPSE** is visible from Asia, Australia, and the Pacific on July 5/6

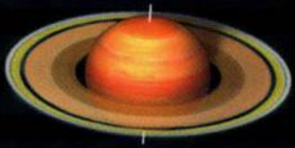
its
July

ERES is at opposition
July 7


6
5
4
3
2
1
31
30
29
28
27
26
25
24
23
22
21
20

light-blue line.



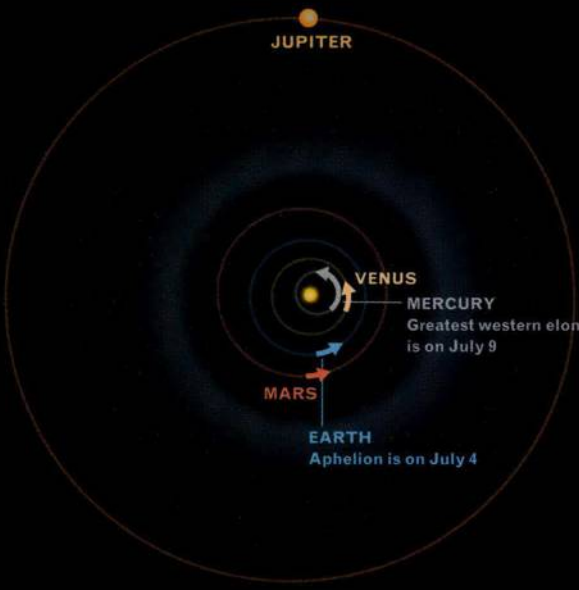


| JUPITER | SATURN | URANUS | NEPTUNE | PLUTO |
|---|---|---|---|---|
| July 15 | July 15 | July 15 | July 15 | July 15 |
| –1.9 | 0.2 | 5.7 | 7.8 | 13.8 |
| 32.7" | 16.9" | 3.7" | 2.3" | 0.1" |
| 100% | 100% | 100% | 100% | 100% |
| 6.037 | 9.812 | 19.100 | 29.119 | 29.625 |
| 5.110 | 9.084 | 19.974 | 30.101 | 30.402 |
| 6h01.9m | 4h36.7m | 21h46.3m | 20h40.6m | 16h51.4m |
| 23°10' | 20°21' | –14°14' | –18°11' | –11°51' |

## The Planets in Their Orbits

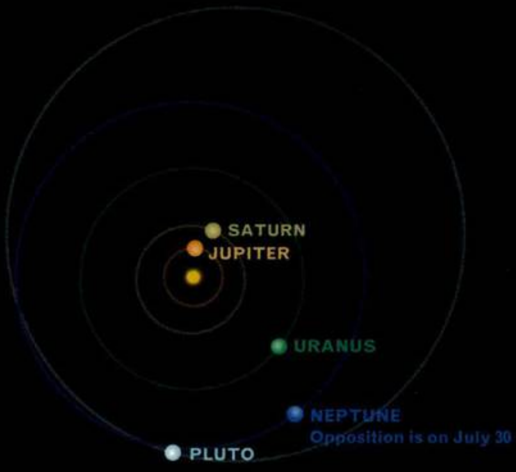
Arrows and dots show planets' positions during the month.

CALLISTO


JUPITER
VENUS
MERCURY
MARS
EARTH

Greatest western elongation is on July 9

Aphelion is on July 4


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

Opposition is on July 30

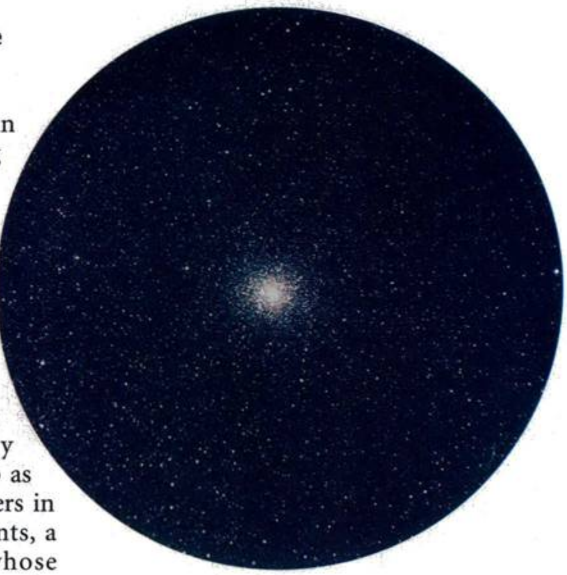
## Butterflies on a Summer's Night

If the splendor of the Milky Way is like a field of white flowers in an alpine meadow on a summer's day, then the beautiful star clusters M6 and M7 are the prominent butterflies floating in the sky. Located halfway between Scorpius's stinger and the tip of Sagittarius's teapot spout, they are easy naked-eye puffs to spot from a dark sky.

These marvelous star clusters are so easy to see that Ptolemy first recorded them almost 2,000 years ago, in the pre-telescopic era. Although he has received credit for the discoveries, chances are these nebulous spots have been recognized since the dawn of humanity, when curious eyes first began watching the skies.

From the northern vantage points of Europe and Canada, Sagittarius and Scorpius unfortunately wallow in the horizon murk, forcing observers to use binoculars to get a glimpse. On the other hand, small backyard telescopes instantly reveal the wondrous collection of bright stars scattered across each field.

The northern cluster, M6, was nicknamed the "butterfly" by French astronomer Camille Flammarion. He enthusiastically described the bright stellar group as "one of the most attractive clusters in the heavens for small instruments, a completely charming group whose arrangement suggests the outline of a butterfly with open wings."



**Globular cluster M22 provides one of the finest sights in Sagittarius.** Jack Newton

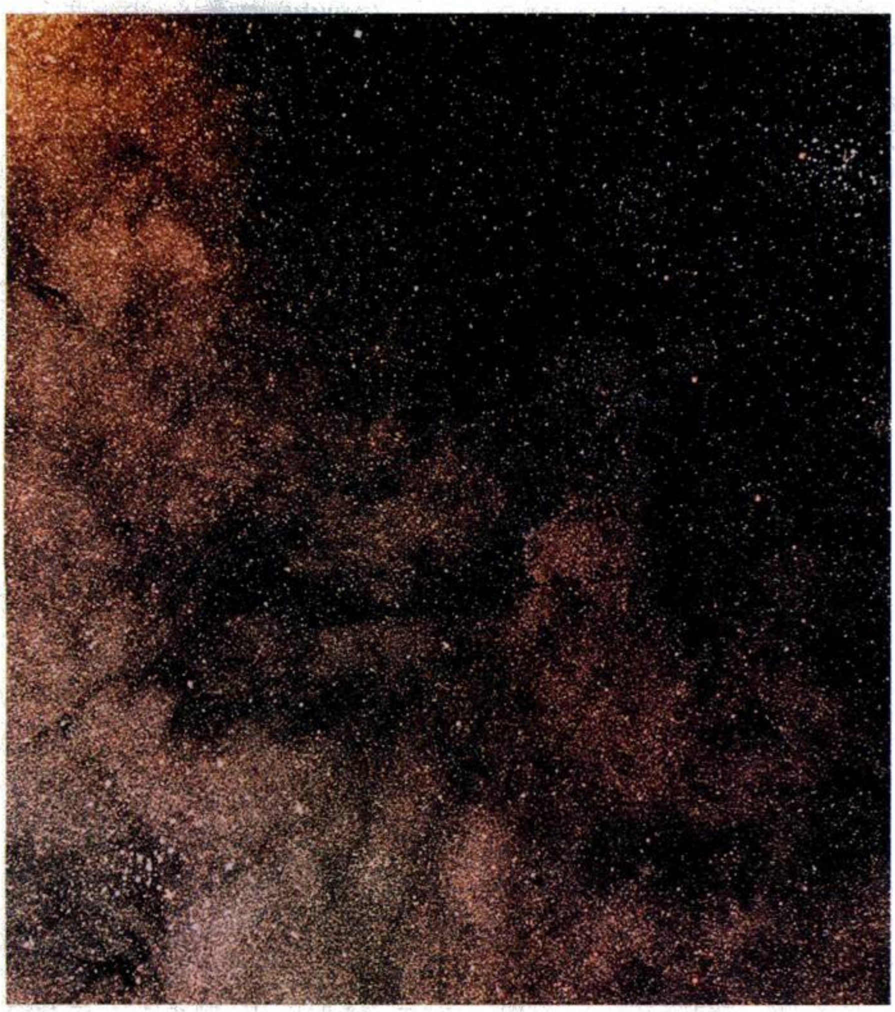
The southernmost cluster of the two, M7, is richer in brighter stars and readily resolves with binoculars. Should you ever get the chance to travel south, make sure these two clusters top your list of "must see" objects. The dense starfields of the Milky Way flowing behind M7 elude description.

## Globular Grazing

As you follow the asteroid Ceres this month, you'll run into a round, gray fuzz. This is the distant globular star cluster Charles Messier numbered 54.

At low power in a small scope, M54 shows no sign of individual stars. In a dark sky with a 10-inch scope at high power, you may begin to spot some granularity as its 15th-magnitude stars pop in and out of view. The great 19th-century observer John Herschel was able to resolve M54 into countless stars using his lower-tech 18-inch polished metal mirror.

Next, swing your scope over to M22, one of the sky's best (and closest) globulars, just northeast of the star at the top of Sagittarius's teapot lid. Its brightest stars shine at magnitude 10.7, easily within reach of a 4-inch scope. An 8- to 10-inch scope at 250x allows you to resolve stars right in the core.



**The bright star clusters M6 and M7 lie amid a rich Scorpius Milky Way star field that is ideally suited for binoculars.** Jason Ware

# sky Show

## Mars and Neptune at Their Best

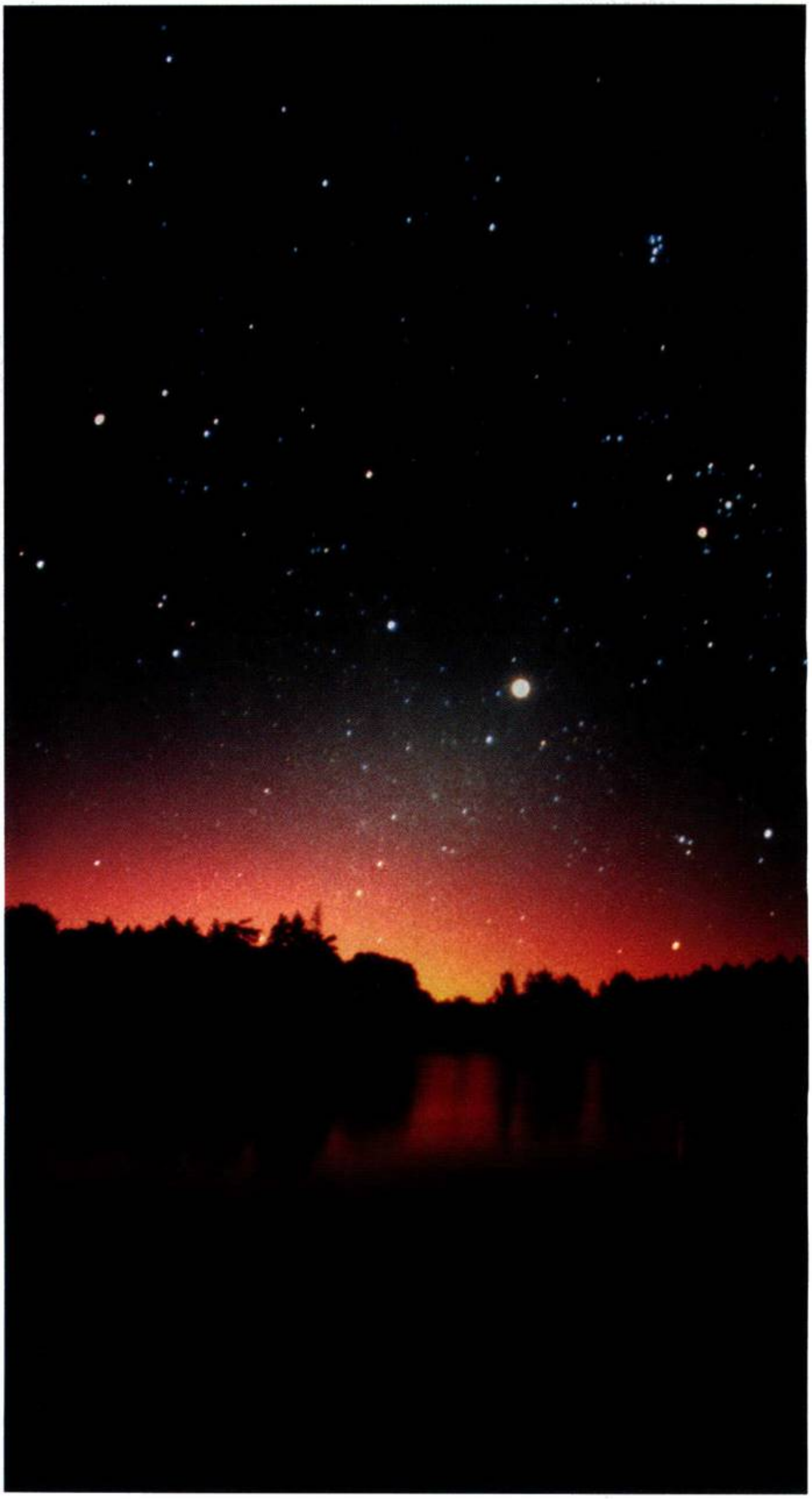
The month of July opens dramatically with a waxing moon and the planet Mars standing high in the south-southeast shortly after sunset. Mars is at its best for June and July and better than it has been for a decade. Mars outshines its neighbor, Antares, 7° to the west. The Red Planet's magnitude soars to –2.1. On July 2 the three objects, Mars, the moon, and Antares, form a noticeable triangle that attracts attention.

**Mars** puts on a fine display this month and is well-placed for viewing. It shines brightly in the southern region of the constellation Ophiuchus, the 13th and often overlooked constellation of the zodiac. Mars passed opposition on June 20, marking the middle of its best period for viewing. Spanning 20" on July 1 and shrinking to 17" by July 31, its apparent size diminishes rapidly as Earth pulls ahead of Mars in its faster orbit, so use every opportunity to observe this orange-hued world.

Telescopically, Mars represents the biggest challenge of all the planets due to its small size. Medium-sized telescopes (8 inches and up) will show Mars quite well, but larger scopes offer much more. Remember that the apparent size of Mars is smaller than the crater Copernicus on the moon. Check out the moon to give yourself an idea of what to expect when viewing Mars.

During the first two days of July you'll find the magnitude 7 globular cluster, M19, lying north of Mars and within the same low-power telescopic view. Within days, Mars moves farther west in its reverse (retrograde) path, caused by Earth's orbit overtaking that of Mars.

Features on Mars prove fascinating to follow. Each night a similar face presents itself to observers, due to the almost identical rotation period of Mars compared with Earth. In early July, the dark feature called Solis Lacus appears. By the end of the second



**Venus hangs out with winter stars in the predawn sky on July 25, 1993.** Jerry Schad

## Central Meridian Longitudes on Mars

| Date | Longitude on Mars on C.M. | | |
|---|---|---|---|
| **June** | **10 P.M.** | **Midnight** | **Principal Features** |
| 31 | 64° | 94° | Solis Lacus, Tharsis Desert |
| **July** 4 | 28° | 58° | |
| 9 | 344° | 14° | Sinus Sabaeus |
| 14 | 299° | 329° | Syrtis Major |
| 19 | 254° | 284° | Hellas |
| 24 | 207° | 237° | Mare Cimmerium |
| 29 | 161° | 191° | |

week of July, the well-known dark feature, Syrtis Major, sits in a central location on the martian disk. By the third week, Syrtis Major slips from view, and the bright region called Hellas dominates, perhaps to be mistaken for a polar ice cap.

If you've never seen **Neptune** before, this month presents your best chance to spot it. Neptune passes very close to the magnitude 5.1 star, Upsilon (u) Capricorni, easily found in binoculars or by the unaided eye from dark sites. Check the location of Upsilon Cap using a star chart. Pointing your scope in that direction, you will see Neptune as well. Upsilon Cap is a red star, providing a lovely color contrast with Neptune's distinct blue cast. Neptune is much fainter, shining at magnitude 7.8. On July 20, the giant planet passes a mere 5" south of Upsilon Cap — an excellent opportunity to see a distant planet move slowly relative to a background star from night to night. Neptune reaches opposition (opposite the sun in the sky) on July 30 when it lies 2.7 billion miles from Earth.

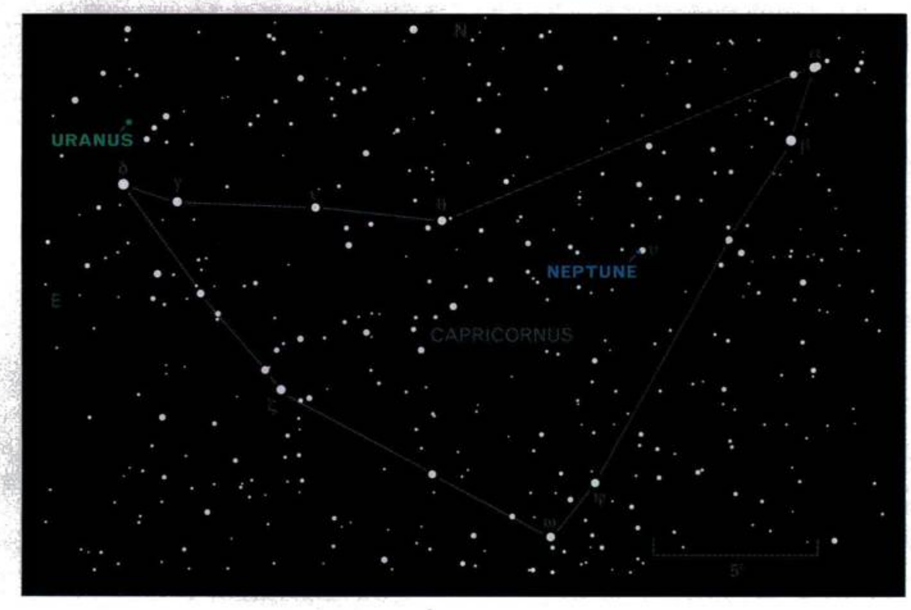
**Uranus** is almost as easy to find as Neptune, and that's because it lies 2° north of Deneb Algedi, the magnitude 2.8 star at the northeastern end of Capricornus. The seventh planet brightens to magnitude 5.7 in time for next month's opposition. Look for the three distinctive stars of 5th and 6th magnitude in a straight line to the north of Deneb Algedi. Uranus moves closer to the lower pair, showing an ever-changing aspect of the triangle formed between the planet and the two stars. In early August Uranus passes between the lower pair.

Tremendous planetary action occurs in July's early morning skies. Three brilliant planets pop over the eastern horizon before dawn. **Venus** rises first, shining brilliantly at magnitude –4.1. It lies 6° south of the Pleiades for a few days around Independence Day (July 4). **Saturn** rises shortly after Venus as dawn breaks in early July, but watch them on following mornings as Venus and Saturn close in on each other — purely a line-of-sight effect, of course, but very photogenic even so. Saturn shines at magnitude 0.2. By July 15, only a 43" gap of sky separates the two planets, though in reality Saturn is 820 million miles farther away. The spectacular pairing, combined with the backdrop of the Hyades and Aldebaran, rises three hours before the sun.

The duo of Venus and Saturn on July 15 is a warm-up for the spectacular view that awaits the early riser on July 17 when a lovely crescent moon joins them. Aldebaran also lies nearby, and all four objects (Venus, Saturn, the moon, and Aldebaran) lie within a 4° circle. Watch between 4 A.M. and 5 A.M. local time for the best view, by which time Jupiter rises.

Later the same day, during daylight on July 17, the crescent moon occults Venus for observers across the entire United States. The event takes place about noon for observers in the Mountain Daylight time zone, earlier for those farther west, and later for those in the east.

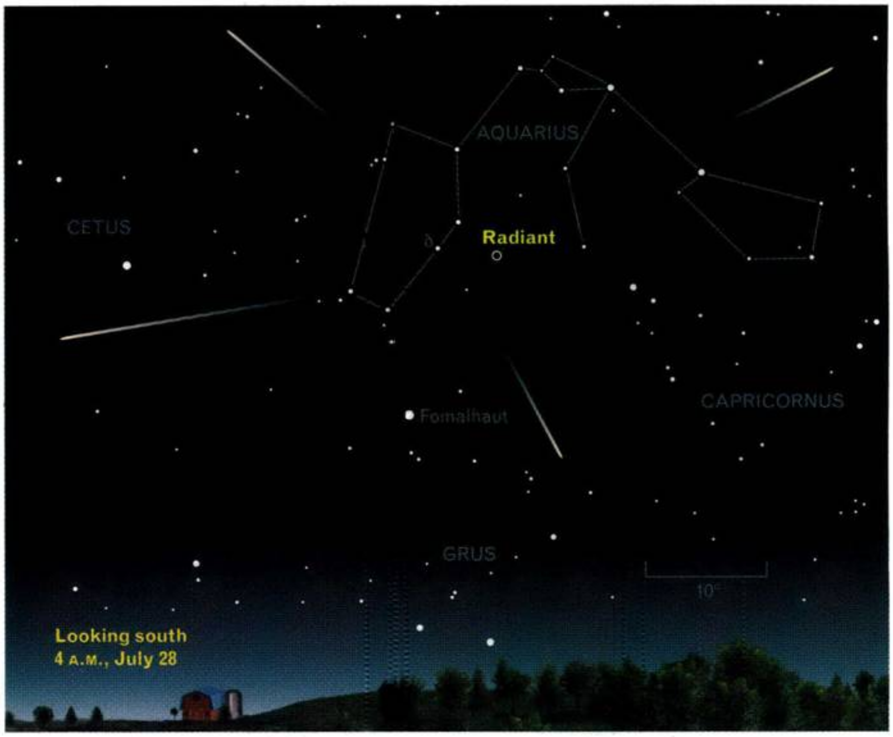
Returning to dawn, **Jupiter** rises 1 hour and 40 minutes before sunrise. It's quite obvious at magnitude –1.9, even in a brightening sky. **Mercury** joins Jupiter for a few days, passing 1.9° south of Jupiter on July 13, at magnitude 0. Mercury reaches greatest elongation west of the sun on July 9 at magnitude 0.4 and brightens each day. By July 17 it shines at magnitude –0.9 and lies only 45' southeast of the slim crescent moon. Later the same day the moon occults Mercury for observers in Alaska and the extreme northwestern United States.



# Meteors and Moons

## Summer Meteors

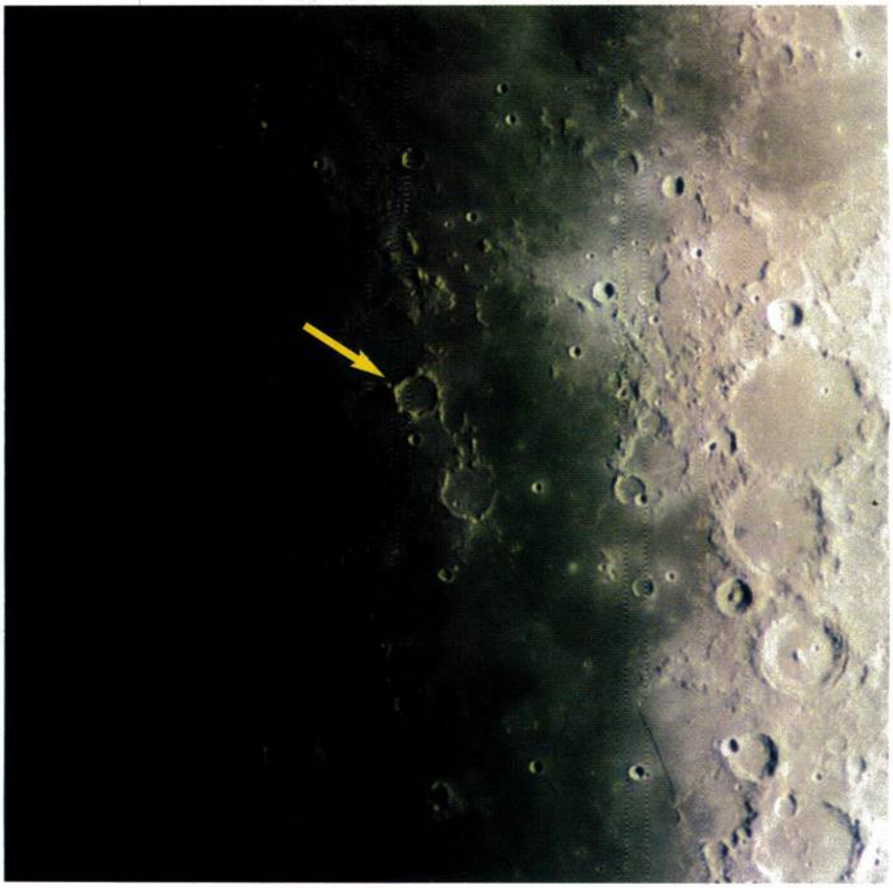
The end of July is particularly active for a number of minor meteor showers. This month is also the time of the early build-up for one of the strongest performers of the year, the Perseid meteor shower. Included in the activity is the Delta Aquarids during the last week of July, which can produce up to 20 meteors an hour. The Alpha Capricornids often produce bright, slow fireballs, but both showers are affected strongly by moonlight through midnight. Watch in the early morning hours for the coming of the Perseid shower after July 17.



## Parry Crater

Lying in the western region of the moon, south of Mare Nubium, is a collection of three fragmented craters: Fra Mauro, Bonpland, and Parry. The sun rises on this section of the moon shortly after first quarter. Fra Mauro was made famous when the Apollo 14 astronauts, Alan Shepard and Ed Mitchell, landed just a few miles north of the fragmented crater. Thirty-mile-long Parry is the youngest and most complete of the three craters in this area, although its southeastern wall is broken by a rille. A small craterlet impinges its southwestern wall, and a prominent rille running north-south along the inner western wall shows up in most scopes.

Sunset on Parry, which occurs near last quarter, is dramatic, and if the timing is right you'll see the pointed shadows of the crater walls. Watch for 30 minutes or so to spot the amazing changes in shadow lengths. The crater walls of Parry resemble a broken chain more than mountains, indicative of its significant age compared to a crisp, fresh crater such as Copernicus, which lies to the north. There's no central peak, but here's a challenge: Can you spot the two tiny craters on the flat crater floor? You won't be able to see the Apollo 14 site, nor the nearby site where Apollo 12 set down.



**Parry crater (arrow) offers rich shadow views at sunrise and sunset.** Franz Kufer

### Ceres Celebrates Two Centuries Since Its Discovery

Two hundred years ago, on the night of January 1, 1801, the Italian monk Giuseppe Piazzi discovered the last piece of the solar system puzzle: the "missing planet" that was thought to lie between Mars and Jupiter. Instead it turned out to be piece number one of the asteroid belt. At 625 miles (1000 km) across, Ceres is the largest of the rocky, irregular bodies. Even if you took Ceres and all the tens of thousands of asteroids discovered since then and compacted them, the result would be considerably smaller than Mars.

As far as we know, the streets of Palermo, Italy, on that night were not disturbed by echoing shouts of "Eureka!" We might presume the moment was marked like many significant discoveries, with some sort of, "Hmm, that's odd." Piazzi noticed a star out of place and the following night recognized that it had moved. In essence, this is how we still find asteroids today, by their motion against the background sky, but with digital cameras instead of our eyes.

From an urban backyard with a 3- or 4-inch scope, you can readily jump over to Ceres near the base of the teapot asterism in Sagittarius. Luckily, in this area not many stars shine brighter than Ceres's magnitude 7.5. Just to be sure, make a quick sketch and return a day or two later to see which "star" moved.

On the evening of the 7th, Ceres forms a tight pair with a brighter 6.3-magnitude star to its south. From the 15th through the 17th, it slides only 13' south (a bit less than half the moon's apparent diameter) from Zeta (ζ) Sag, the lower left star of the teapot.

The largest asteroid gives us a treat on the evening of the 25th when it grazes the southern flank of the bright Sagittarius globular star cluster M54. Ceres will outshine any of the cluster stars, whose brightest members glow at 15th magnitude.

While you are checking out Neptune in Capricornus (see page 63), take a couple minutes to catch asteroid 20 Massalia. On the 27th, Massalia passes a mere 2' south of a 6.5-magnitude companion to Rho (ρ) Cap. At magnitude 9.9, Massalia is more of a challenge than Neptune, but with Rho Cap as a signpost, you should be able to nail it without much trouble. This is a perfect opportunity to watch an asteroid move in as little time as an hour.

### Noctilucent Clouds

No longer the sole domain of the northern skywatcher, the most delicate and majestic phenomenon of the twilight sky is apparently moving south. Last year for the first time, observers in Colorado reported noctilucent clouds. These ephemeral waves and whorls float near Earth's mesopause, some 50 miles (80 km) up, joining the realm of meteors and aurorae. Noctilucent clouds form when water vapor condenses onto meteoric dust to form ice crystals. This is why they look somewhat like the more pedestrian, wispy ice-crystal cirrus clouds. Noctilucent clouds are so thin that they are invisible in daylight, appearing only when the background sky is sufficiently dark.

A popular but as yet unproved conjecture is that global warming is affecting the upper atmosphere's temperature structure, allowing noctilucent clouds to spread much farther south than usual. Keep on the lookout for delicate, cloudy veils that glow with a lovely bluish-white hue. This comes in stark contrast to regular clouds that appear dark against the twilight glow: The sun has set for normal clouds. Noctilucent clouds become visible only in summer and when the sun sits between 6° and 12° below the horizon, either in the northwest or northeast.

A word of caution: Don't trust yourself completely under moonlight because normal cirrus clouds can masquerade as noctilucent clouds. ■

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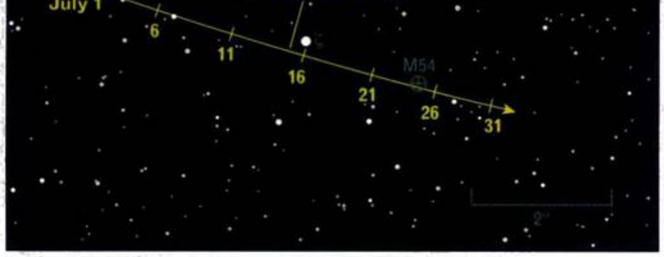
*Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.*



**Noctilucent clouds (below right) offer a ghostly, rare sight.** Pekka Parvianen/Lockheed

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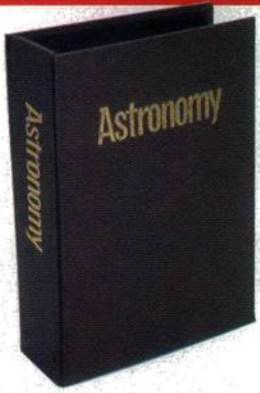

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# Go To The NexStar On Your List

*Celestron's NexStar 60 GT, 80 GT, and 114 GT telescopes offer go-to convenience at affordable prices.*

**by Glenn F. Chaple, Jr.**

I'm a 19th-century astronomer stuck in a 21st-century world. While my peers venture out with CCD cameras affixed to computer-driven telescopes, I stargaze with no-frills, small-aperture scopes. But much as I hate to admit, I'm finding that traditional technology largely fails small-scope users and discourages novices. Let's face it: Many beginning observers want an easy way to view astronomical objects without learning the sky first.

Enter Celestron International and its series of small-aperture scopes. Patterned after their bigger go-to brothers (the NexStar 5, 8, and 11), these NexStars employ a computerized hand control that allows users to select from a large list of sky objects and order

**Celestron's NexStar 60 GT, 80 GT (pictured at left) and 114 GT models all feature easy assembly and employ an identical keypad (above) and aluminum tripod. These user-friendly telescopes may herald a surge in popularity for amateur astronomical observing.** All photos: *Astronomy:* Jim Forbes the telescope to locate the target. I tested the NexStar 60, 80, and 114 GT. The NexStar 60 and 80 are refractors (2.4-inch f/11 and 3.1-inch f/5, respectively). The NexStar 114 is a 4.5-inch f/9 reflector with a deceptively short tube (it has a built-in Barlow lens that increases the scope's focal length).

Each NexStar model is lightweight and extremely portable. All three require some assembly using a Phillips screwdriver. Instructions in the manual are generally clear; expect each to take about half an hour to assemble. The mount — essentially the same on all three — is a vast improvement over what I've encountered with earlier scopes in this size range. Steady and relatively free of vibration, the mount is stabilized by a triangular accessory tray. My only complaint is that the tray lacks slots for securing extra eyepieces.

Optically, all three models performed well. The NexStar 60 did a fine job on the Orion Nebula, Crab Nebula (a first for me with a scope of this size), Jupiter, Saturn, and the binary star Castor. The repertoire of the NexStar 114 was equally varied. This scope has a rather large secondary mirror, but the overall light grasp (I was able to glimpse a magnitude 13.3 star) is hardly impaired by the resulting obstruction. And true to its "rich-field" nature, the NexStar 80 GT was at its best with large objects like the Andromeda Galaxy and Pleiades. I encountered some ghost images when viewing Jupiter with low power, but alleviated the problem by boosting the magnification.

The NexStar 60 comes with three modified achromat eyepieces — 20mm (which provides 35x), 10mm (70x), and 4mm (175x). Both the NexStar 80 and 114 accommodate 25mm and 10mm super-modified achromat eyepieces. All eyepieces worked well, except for the 4mm MA (too much magnification for the NexStar 60 — the upper limit for such a telescope is more like 120x). These eyepieces have the standard 1.25" diameter, not the 0.965" typically found with low-quality, small-aperture scopes.

Each of the NexStars comes with an easy-to-use LED StarPointer finder which is needed only during initial setup. Once alignment is complete, the hand control reminds you to turn it off. After using the StarPointer a few times, my prejudices against LED-type finders abated.

**Thanks to its 3.1-inch diameter, the NexStar 80 GT provides users with a wide field of view great for observing large deep-sky objects.**

**Shown here without its sunshade, the compact yet versatile NexStar 80 GT transports easily to various observing sites.**

## Quick Tech Support

Now for the go-to system: NexStars require 12 volts DC, supplied by a power pack that holds eight AA batteries. (Celestron also offers adapters for powering the NexStar with a 120-volt AC outlet or a car battery). Use of the go-to feature mandates prior alignment and programming.

Auto-alignment consists of pointing the scope toward the northern horizon, entering the date, time, and location, and then sighting the scope on two bright stars automatically selected by the system. Auto-alignment works best from an observing site offering an open, uncluttered horizon. If you move the NexStar for a different view, expect to repeat the alignment process.

While testing the NexStars, I called Celestron's tech support personnel several times. They responded quickly to my live or recorded queries. Initially, I had difficulty getting the NexStar 60 GT to slew back and forth. A Celestron representative discovered that the motor wasn't working properly. A replacement NexStar 60 GT sent out to me worked perfectly.

The NexStar 80 worked nicely at first, but after a half hour, the LCD readout faded and I reluctantly suspended the session. A Celestron tech support person confirmed my suspicion that subfreezing temperatures adversely affect LCD technology. I warmed the remote by placing it in my coat pocket. A word of caution when using either the NexStar 60 or 80 GT: When these scopes slew to an object close to the zenith, the focuser at the base of the tube assembly bumps the mount. The scope freezes in place as the motor continues slewing. I also found that the NexStar 114 GT's power cord often slipped out of its sleeve, causing me to repeat the alignment.

## Get Ready and Go-To

When the NexStar scopes worked (which they all ultimately did), they worked marvelously well. It was a

### Celestron's NexStar 60 GT, 80 GT, and 114 GT Telescopes

**Specifications**

| | **NexStar 60 GT** | **NexStar 80 GT** | **NexStar 114 GT** |
|---|---|---|---|
| **Aperture:** | 60mm (2.4-inch) | 80mm (3.1-inch) | 114mm (4.5-inch) |
| **Focal length:** | 700mm | 400mm | 1000mm |
| **Focal ratio:** | f/11 | f/5 | f/9 |
| **Length of tube:** | 28" | 15.5" | 18" |
| **Size of focuser:** | 1.25" | 1.25" | 1.25" |
| **Eyepieces:** | 20mm MA (35x)<br>10mm MA (70x)<br>4mm SMA(175x) | 25mm SMA (16x)<br>10mm SMA (40x) | 25mm SMA (40x)<br>10mm SMA (100x) |
| **Finder** | StarPointer (LED) | StarPointer (LED) | StarPointer (LED) |
| **Secondary size:** | N/A | N/A | 40mm |
| **Weight:** | 10 lbs. | 12 lbs. | 16 lbs. |
| **Price:** | $299 | $399 | $499 |

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The NexStar 60 GT (above and right) is an affordable beginners' scope that comes with eyepieces that yield 30x, 70x, and 175x.

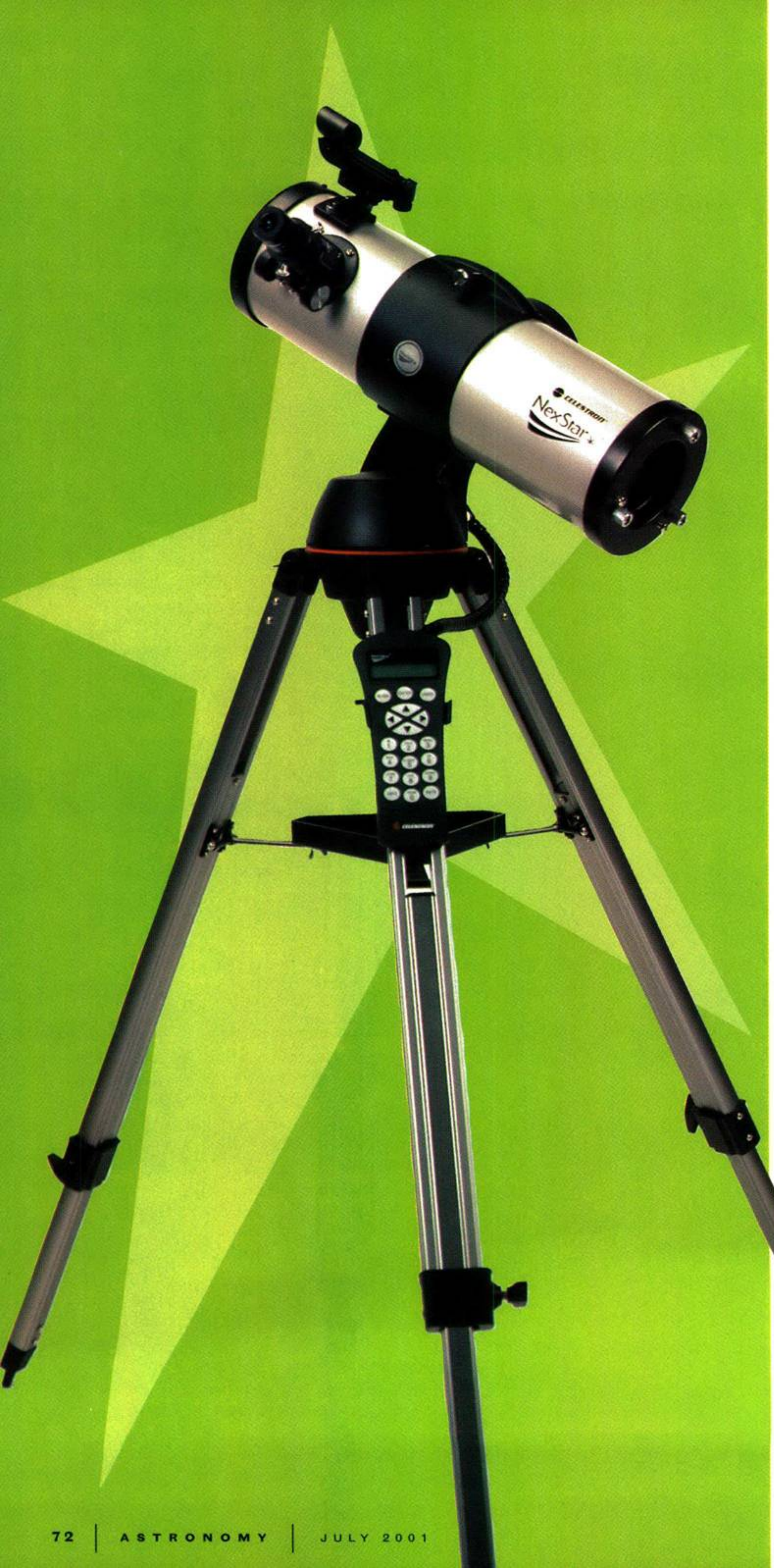
novelty to simply press a button and watch the telescope slew to a particular object. What fun to press "M31" on the hand control, then watch as the Andromeda Galaxy glides into the field of view! I enjoyed viewing the Orion Nebula without having to constantly recenter it. The NexStars' tracking rates weren't perfect, but the scopes held onto a sky object for many minutes before recentering.

Although the go-to database captures a surprising array of more than 4,000 celestial objects, I found some questionable. A beginner might wonder why he or she sees only black space after logging in Pluto, the Horsehead Nebula, or Stephan's Quintet.

However, I was pleased to discover the often-overlooked h3945 — a magnificent gold and blue stellar pair in Canis Major — as a double star selection. My suggestion to Celestron would be to reduce the number of NGC objects and add more double stars, as these cosmic gems are a delightful sight in small scopes.

Veteran observers often grumble that go-to systems allow beginners to avoid learning the night sky. Realistically, many people don't have time for astronomical ground school. In fact, go-to technology may provide the spark that attracts more numbers to our amateur observing ranks.

For instance, in the past when I've taught a unit on telescopes and astronomy to seventh graders, my students greeted the traditional alt-az mounted scopes with mild interest. That changed this year, as I demonstrated a NexStar 60 GT. When I pressed the button on the remote, the telescope began to move with its characteristic whirring sound, and the students let out a collective "Whoa!" I believe a NexStar 60, 80, or 114 GT is a great telescope for someone as young as



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**Celestron's 114 GT features a 4.5-inch aperture, giving this Newtonian reflector 265x the light-gathering power of the human eye.**

12 or 13 — provided he or she has a sincere interest in astronomy and is at least somewhat technically inclined. You'll need a connector cable and Guidestar software (the latter comes with each telescope) to control the NexStar 60, 80, and 114 GTs by a PC.

While anyone used to computers will immediately "get" this system, an adult novice with little or no computer savvy may stumble a bit. I loaned the NexStar 60 GT to a fellow teacher. It took her about an hour to assemble the scope, and after a thorough reading of the manual, she had a great time observing sky objects that had eluded her in the past.

Customer satisfaction is a good indicator of a telescope's success. Local retailers reported brisk sales of the NexStar 60, 80, and 114 GTs as well as their cousins in the ST series (same telescopes, no electronics). No NexStar models had been returned.

How durable are these NexStar models? These scopes and mounts should last for decades. But the electronics in the go-to system may be another matter. Electronics are sensitive and carry a certain risk of failure over time. I think the NexStars are worth the risk. Celestron offers a one-year warranty on its telescopes.

So, did the NexStar scopes turn me into a "technocrat?" Not completely. Next time I travel, I'll still pack my trusty old Astroscan in the car. But chances are you just might see a NexStar GT sitting next to it.

---

*Glenn F. Chaple, Jr., of Townsend, Massachusetts, has been an avid amateur astronomer for more than 30 years.*

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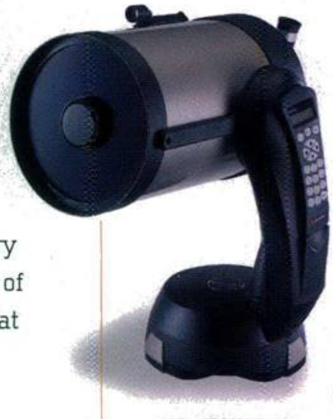

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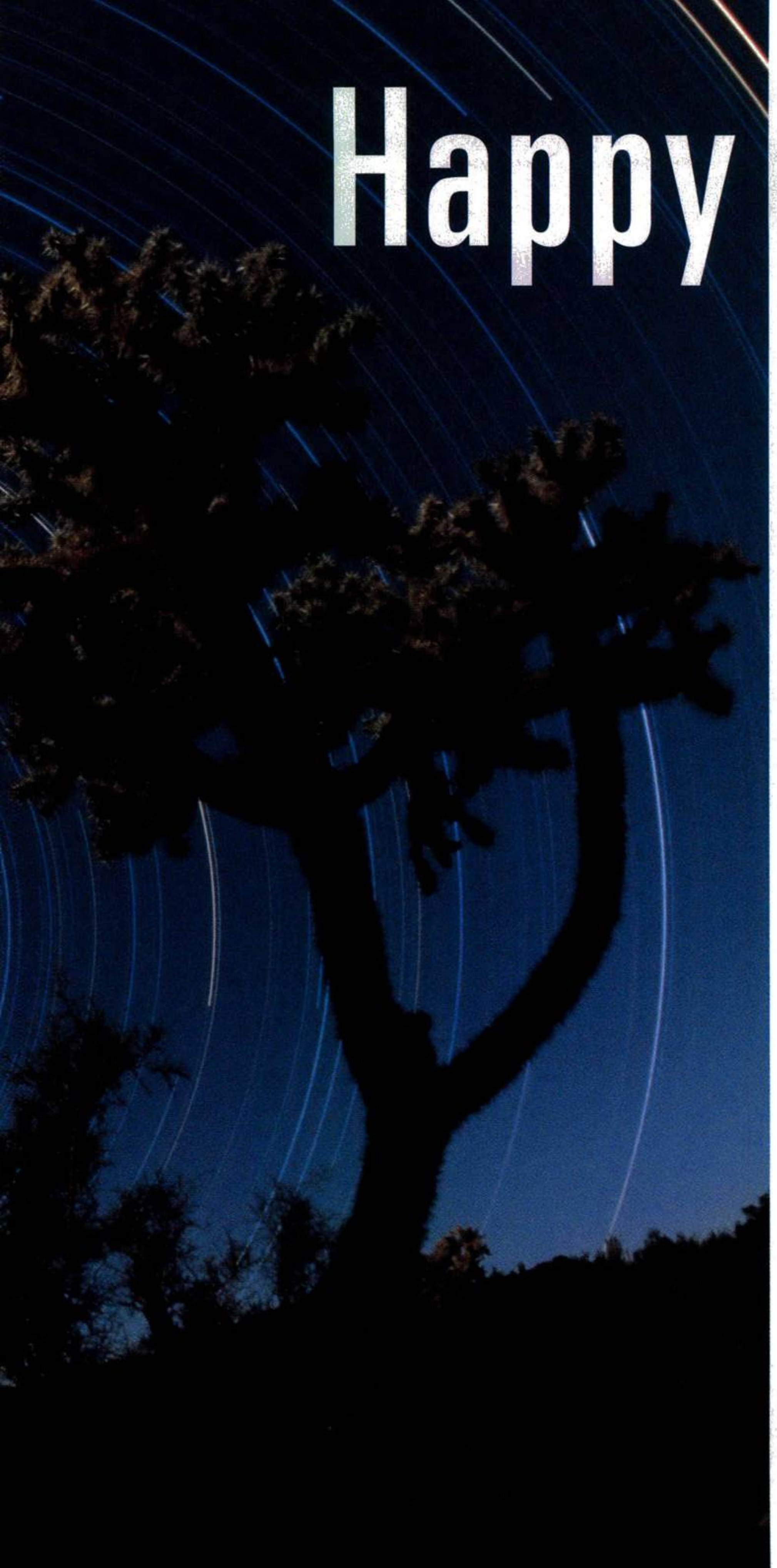
# Happy Trails

*Use these tips to perfect one of the easiest forms of astrophotography.*

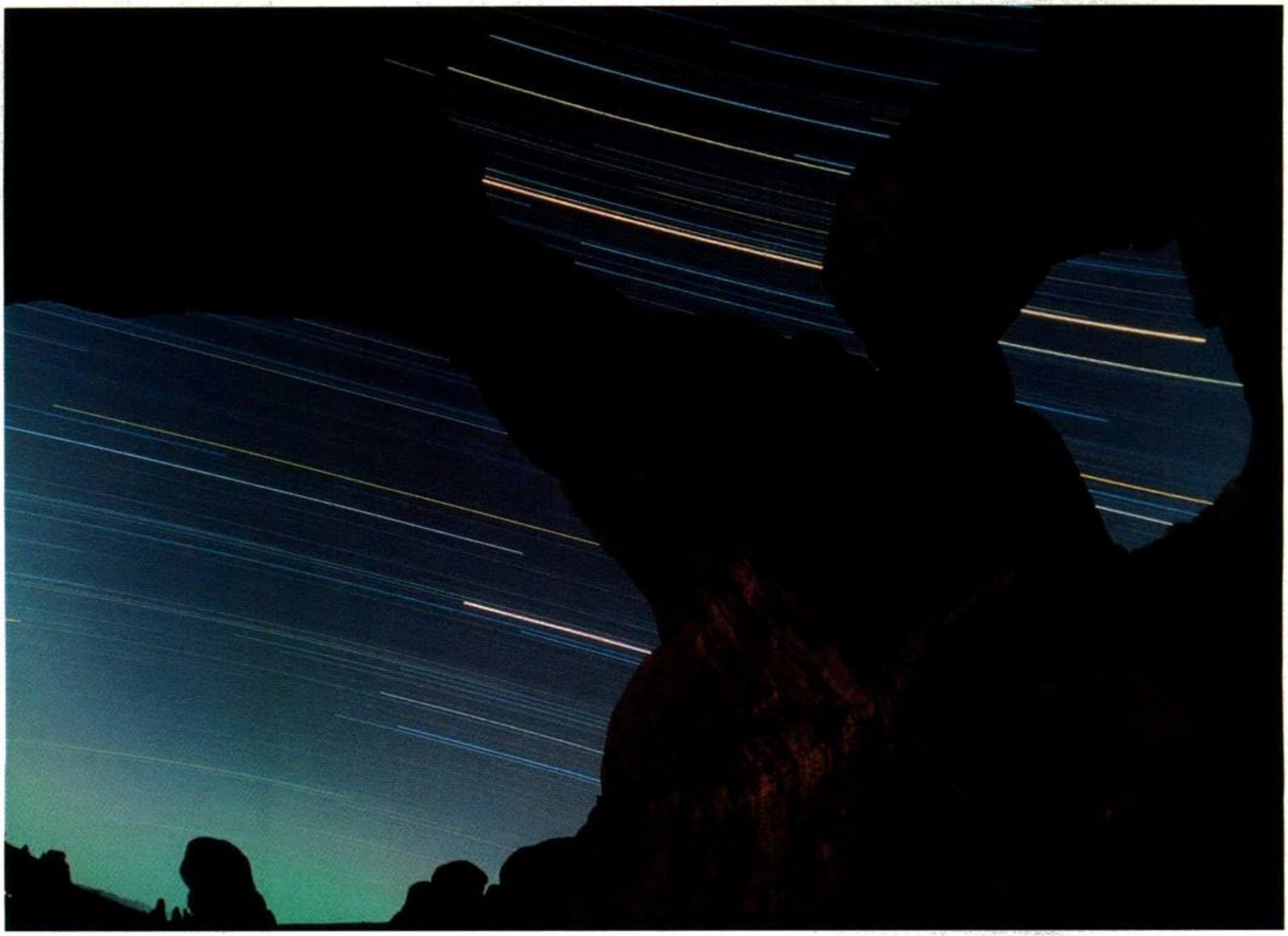
**Photos and text by Eric DeBolt**



The idea behind photographing star trails is wonderfully simple. Just take your old mechanical camera, point it skyward, and leave the shutter open. With patience, practice, and attention, you can take some stunning and artistic images. I will try to help you understand the details that matter most, but the practice and patience are up to you.

Many cameras on the market are capable of making nice star-trail photos. The newer and pricier professional cameras with power-saving, time-exposure modes offer advanced flash functions and

**Circumpolar stars trail over cholla cacti in Organ Pipe Cactus National Monument, Arizona. (16mm lens at f/4, Fuji Velvia 50 film, 10½-hour exposure.)**



incorporate features useful for regular daytime photography. However, if you opt instead for a mechanical camera, you will get a bargain that is also lighter and smaller. But any sturdy mechanical SLR (single-lens reflex) body with a B, or bulb, setting that can accept a cable release will work. The camera shouldn't require battery power to keep the shutter open. In cold weather lithium batteries can die during a single exposure.

Fixed focal-length lenses will nearly always produce sharper, higher contrast trails than zoom lenses will. A high-quality, wide-angle lens will put a dent in your pocketbook. But new equipment buyers should spend the bulk of their money on the lens, because star-trail photos only require the camera shutter to open and close. The cheapest camera body with the finest lens will yield far better results than a discount lens on a professional camera body.

A sturdy tripod is a must, but even the strongest tripod should be weighted down substantially in windy conditions by hanging something heavy from the center post. Set your tripod low with its feet spread wide to ensure a sharp, vibration-free image.

The film you choose merits careful consideration. Different effects can be achieved with small changes in film speed and formulation. Don't cut corners on the least expensive and most important part of the process; ten dollars a roll for the finest professional slide film is a bargain. Each exposure costs about fifty cents, including processing at the best lab. Generally you will only be able to shoot one exposure per camera per night.

**Top: Double Arch at Arches National Park, Utah, frames color star trails. (16mm lens at f/4, Fuji Velvia 50 film, 9-hour exposure.) Above: Rocks in Goblin Valley State Park, California, frame trailed stars. (16mm lens at f/4, Fuji Velvia 50 film, 10-hour exposure.)**

During the long exposures that are necessary for star trails, the highlights will show up but the film will record almost no detail in shadowy areas, so choose slower-speed films to counteract some of this loss. Images shot on faster film yield a sky that is not nearly as dark and too much grain shows next to the star trails. An exposure several hours long at a wide aperture would never work if the bright stars stood still. But Earth turns, and as the stars sweep across the sky they deliver just enough light so as to not overpower any portion of the film or be too faint to be visible. Adjust the aperture for faster or slower film. An ISO 50 film with an aperture at about f/4 is the best choice for the typical star-trail photo. Capturing a close foreground subject in focus demands a greater depth of field, so you might want to try using an ISO 100 film at f/5.6. Slow black-and-white films can produce some stunning images, but the true colors of the stars are hard to pass up. Keep a detailed notebook or journal of your choices to see what works and what doesn't.

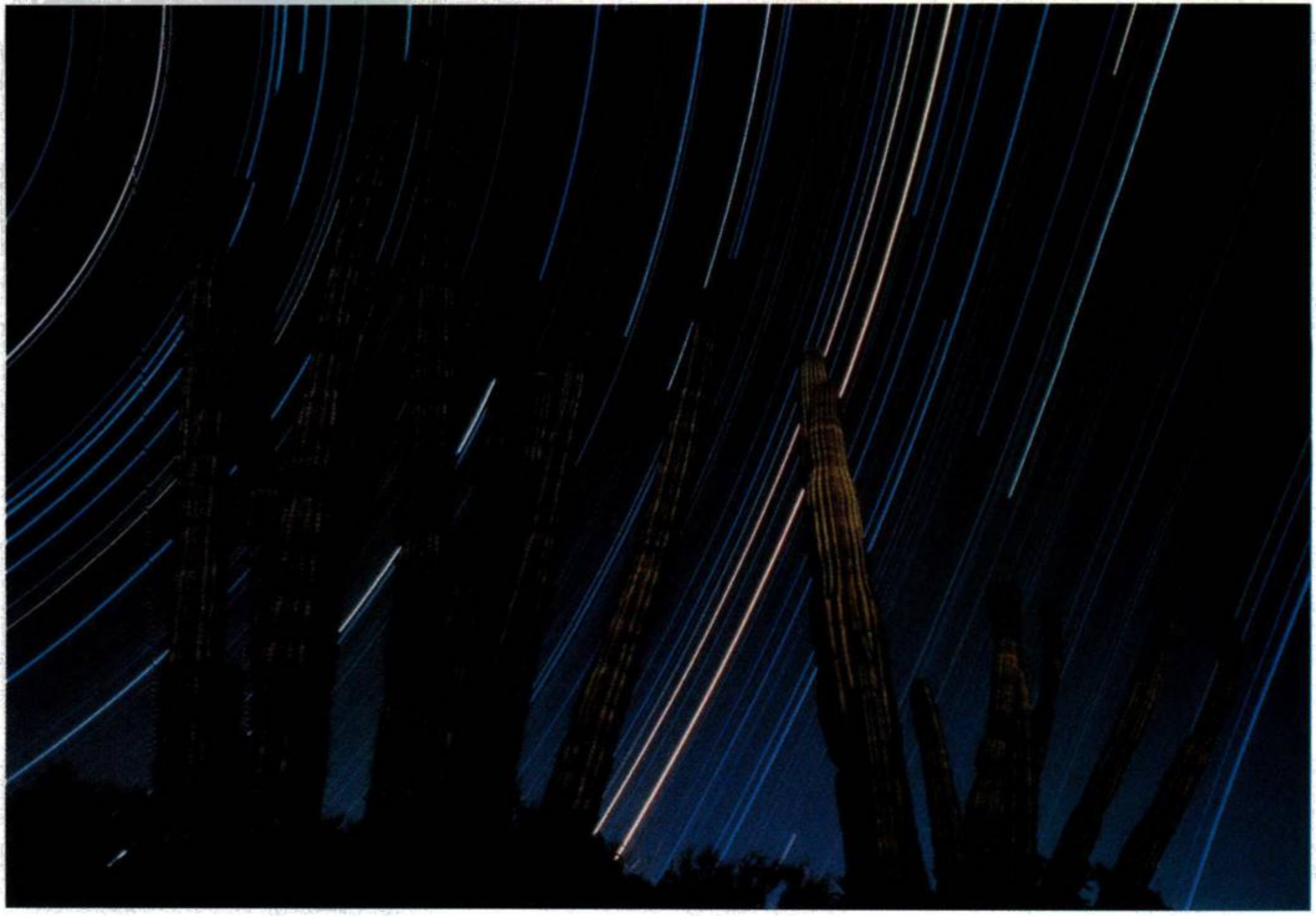
### The Right Place at the Right Time

Photos taken in urban areas will always come at the cost of the number of visible stars and the depth of black in the background sky, so pick a location far from high populations. In addition, find a place with low humidity. The dry air of a desert allows subtle star colors to record on film. Some of the best locations for astrophotography are mountaintops surrounded by a desert, far from civilization. The state and national parks of the four-corners states — Arizona, Colorado, New Mexico, and Utah — are ideal.

The natural attractions in America's parks make fascinating foregrounds by interrupting the star trails and creating silhouettes. This can add missing perspective to these nighttime photos. Access to some of the desirable locations in parks may require special consideration; some of the roads and trails are closed from dusk to dawn. The better you learn the terrain during the day, the easier and safer it will be to maneuver and compose the best shots at night.

The arc length of your star trails depends on how much Earth turns while the shutter is open. The best results come from opening the shutter about two hours after dusk and closing it at least one hour before dawn. But this long of an exposure requires extremely dark skies. Six hours is one-fourth of a day, which equals ninety degrees worth of arc. The best shots seem to be closer to one hundred and twenty degrees, or about eight hours. Therefore, winter is the ideal season for star-trail photography because the nights are longest. Just before and after the new moons of winter you

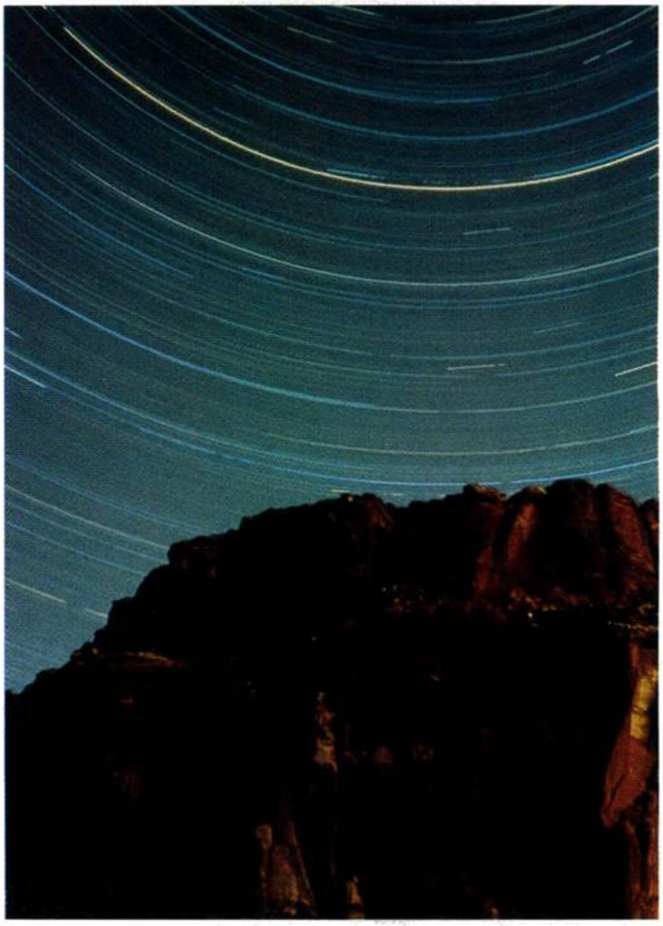
**Left: Stellar arcs grace the "goblins" at Goblin Valley State Park. (20mm lens at f/2.8, Fuji Velvia 50 film, 9½-hour exposure.)**
**Below: Organ pipe cacti in Organ Pipe Cactus National Monument frame star trails. (16mm lens at f/4, Fuji Velvia 50 film, 10½-hour exposure.)**

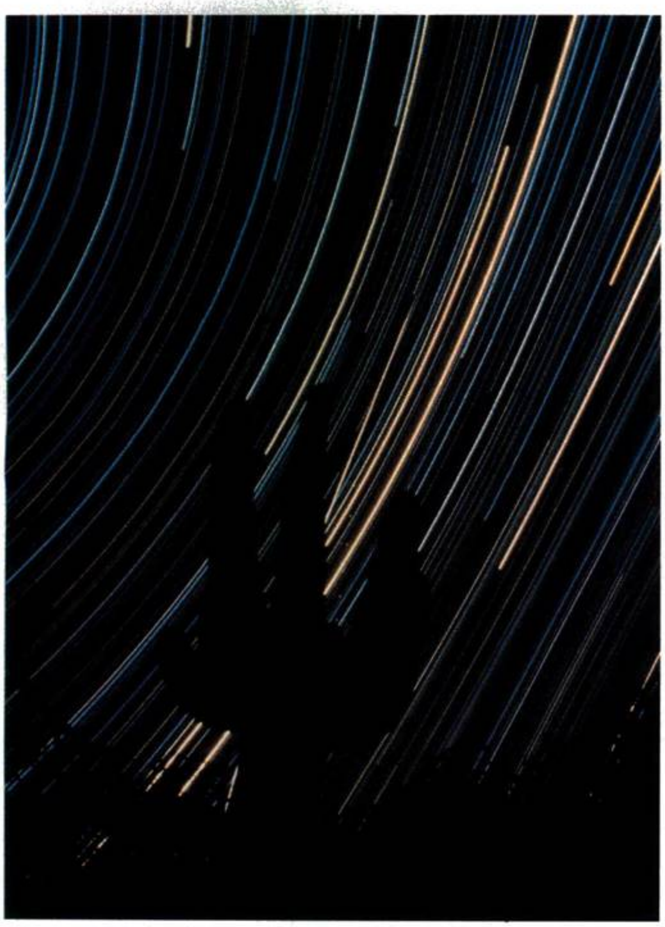


## Weather Not Fit for Man or Photography

You're five hours into a beautiful star-trail exposure only to find that the lens has become encrusted in ice crystals or totally covered over in dew. Yes, this does ruin the exposure. Egads! What can you do to fix this problem next time?

Out of desperation I stopped using filters and applied antifog treatment directly to the front and back elements of my precious lenses. This worked most of the time in mildly foul conditions and does not appear to have damaged the daytime performance or value of my lenses. Out of respect for fine optics I recommend that you try treating a cheap UV filter first. You may arrive at a solution without having to touch the delicate multicoatings on your lens. You should be able to tell if there is rain, snow, or sleet in the forecast, but sometimes the clouds roll in from nowhere. If you are in doubt, you can wrap the camera in plastic or use a protective housing. Try to secure it so the wind cannot upset it or the camera. — *E. D.*





**Above: Moonlit stars trail over Capitol Reef National Park, Utah. (35mm lens at f/1.4, Fuji Velvia 50 film, 11-hour exposure.)**
**Left: A lone Saguaro cactus highlights star trails over Mescal, Arizona. (16mm lens at f/4, Fuji Velvia 50 film.)**

might be able to expose for over ten hours. This time of year also means fewer tourists in the parks to spoil your shots, and the cold, crisp air will let you record the subtle hues of dim stars.

Awareness of the moon's cycle is critical. To avoid washing out the star trails in bright moonlight, it's best to shoot on or near a new moon. However, the moon need not be your enemy. With careful timing, you can record its rise or casting an otherworldly light onto subjects that would ordinarily be silhouettes. Try to select camera positions, lenses, and settings in daylight, but be flexible because things can look quite different by starlight alone.

After experimenting with basic photos, you may wish to add some light of your own for a more creative image. Using different color filters on different parts of the foreground with a little bit of moonlight before closing the shutter can bring various moods to your images. Just don't overdo it.

If you can remember all these tips and add your own creative genius to them, you will be taking fantastic star-trail photos your first time out. ▪

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*Eric J. DeBolt lives in Seattle, Washington, and has had his star-trail photos published in previous issues of* Astronomy *magazine and in the* Astronomy *1997 calendar.*

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# Ara, Triangulum and Apus

*A spectacular myriad of deep-sky objects fills this southern trio.*

**By Tom Polakis**

The clear skies and warm air of summer offer observers in southern latitudes the opportunity to capture many astronomical gems with their scopes, binoculars, and even the naked eye. This month's tour of the nighttime sky includes three constellations brimming with prime observing objects. These three figures are close enough to the Milky Way's plane to contain a variety of clusters and nebulae, along with a few scattered galaxies.

The northernmost of these constellations, Ara, the Altar, is awash with clusters, lying less than 30° from the Galactic center. A small quadrilateral of 3rd- and 4th-magnitude stars becomes immediately apparent south of the Stinger of Scorpius. Of these four stars, Beta ($\beta$), Zeta ($\zeta$), and Epsilon ($\varepsilon$) Arae appear distinctly orange, while Alpha ($\alpha$) Arae shines an icy blue. In terms of distance, though, Zeta Arae is the odd one, at least twice as far away as the other three, at more than 800 light-years. The luminosities of these four stars vary widely, ranging from Epsilon Arae, 120 times as bright as the sun, to Zeta Arae, which is as bright as 3,000 suns.

Immediately south of Ara lies Triangulum Australe, a constellation with a pattern even more apparent. But as is typical, this pattern is illusory. The stars of this constellation, also known as the Southern Triangle, all shine brighter than 3rd magnitude. The stars Alpha, Beta, and Gamma ($\gamma$) Trianguli Australis reside 540, 40, and 190 light-years away, respectively.

Moving one constellation farther south and even farther from the Galactic plane brings us to Apus, the Bird of Paradise. Finding the bird in this modest assortment of 4th-magnitude stars requires some imagination. Apus is circumpolar, visible all year long for Southern Hemisphere dwellers, situated opposite of the South Celestial Pole from the Large Magellanic Cloud.

Our tour of deep-sky objects begins in the north with the open cluster **NGC 6250**. This modest cluster is best found by making an equilateral triangle with the westernmost stars of the Stinger of Scorpius. Nearly a dozen stars brighter than 12th magnitude glow over a 10' area in NGC 6250, along with a wide scattering of a couple dozen much fainter stars.

Some 4° to the southwest lies a region of emission and reflection nebulosity involved with the Ara OB1 stellar association, a group of young, hot stars bound by gravity. **NGC 6188** shows up as a milky haze 15' across in a rich field. The nebula's west edge terminates abruptly against a dark nebula. Use low magnification and sweep across the field east to west to find the cluster **NGC 6193**, nearly centered inside the nebula and as interesting visually as the glowing gas. Astronomers have dated the stars in this cluster at about 3 million years, very young by astronomical standards. Separating the 15'-diameter cluster from the surrounding Ara OB1 association, which is 1° across, is difficult.

While looking at NGC 6193, don't miss the double star **DUN 206**, which contains the two brightest stars in the area. Both stars, blue-white (spectral type O), glow at magnitudes 6 and 7, and are separated by only 10". The best view results from using moderately low magnifications.

Artwork at left from "The Glorious Constellations," © 1991, Harry N. Abrams, Inc.

In 1995, astronomers compiled a list of 18 probable pairs of open star clusters separated by less than 65 light-years. The list includes **NGC 6208**, a modest assortment of several dozen stars near Epsilon Arae, and thought by astronomers to be physically linked with the much richer cluster **NGC 6152**, which lies 3° to the west-northwest in Norma. NGC 6208, 15' across, appears as a well-defined sprinkling of stars that are slightly brighter than the very rich surrounding fields. Small binoculars at a dark site will afford the best views of NGC 6208.

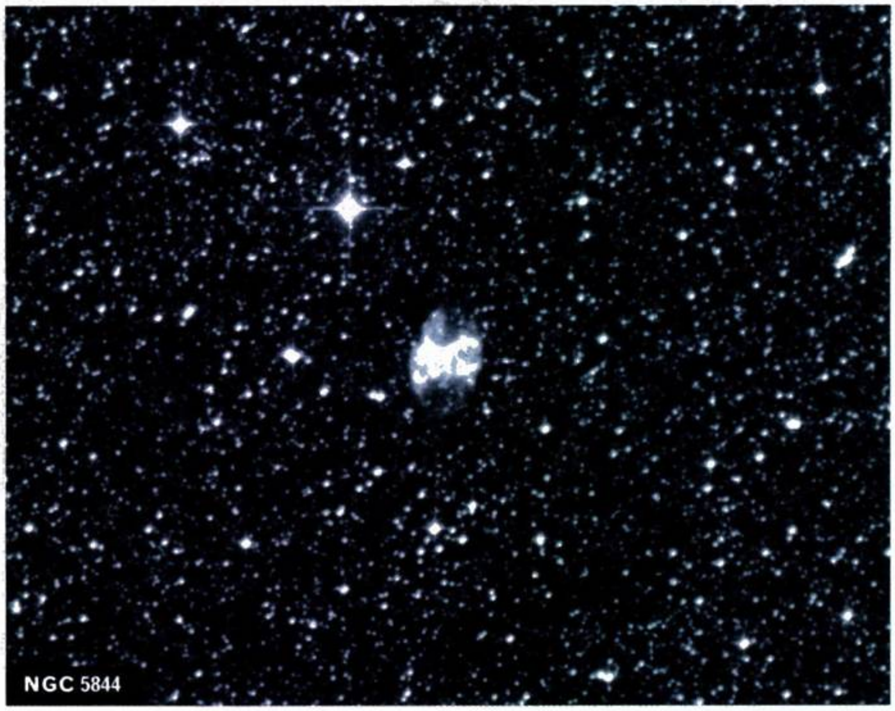
About 2½° northwest of Eta (η) Arae lies a good example of an eclipsing binary star, one whose light dims when a fainter companion star passes between it and Earth. **R Arae** typically shines at magnitude 6 until an eclipse occurs, when it dims by a full magnitude. These eclipses occur like clockwork every four days, 10 hours, and 12 minutes. The best comparison stars lie 2° to the east-southeast, between Eta and Zeta Arae, where a pair of stars separated by 12' display the range of brightness that R Arae covers. In this case, binoculars are the best instrument for making magnitude estimates.

Moving farther out, the next target is a distant galaxy that presents its spiral nature to modest telescopes. **NGC 6221** is conveniently situated 25' east-southeast of Eta Arae. This barred spiral galaxy 70 million light-years away interacts with **NGC 6225**, which lies 10' to the northwest. In a 10-inch scope, NGC 6221 appears as a faint haze 2' across with a central bar oriented east-west. Faint spiral hints appear in the form of a northward-pointing arm radiating from the eastern end of this bar. Long exposures show this arm arcing almost 180° to the western end of the bar. Seeing this feature requires a very large telescope.

From the northern end of Ara, it's easy to find the globular cluster **NGC 6352**, which resides in the Milky Way's disk approximately 25,000 light-years from the sun, and half that distance from the galaxy's center. A 6-inch telescope brings out the mottled appearance of the cluster, with semi-resolved stars some 3' across. In a 12-inch scope, the scattered stars are well-resolved, and the cluster's size increases to nearly 6'. A packed star field surrounds the globular.

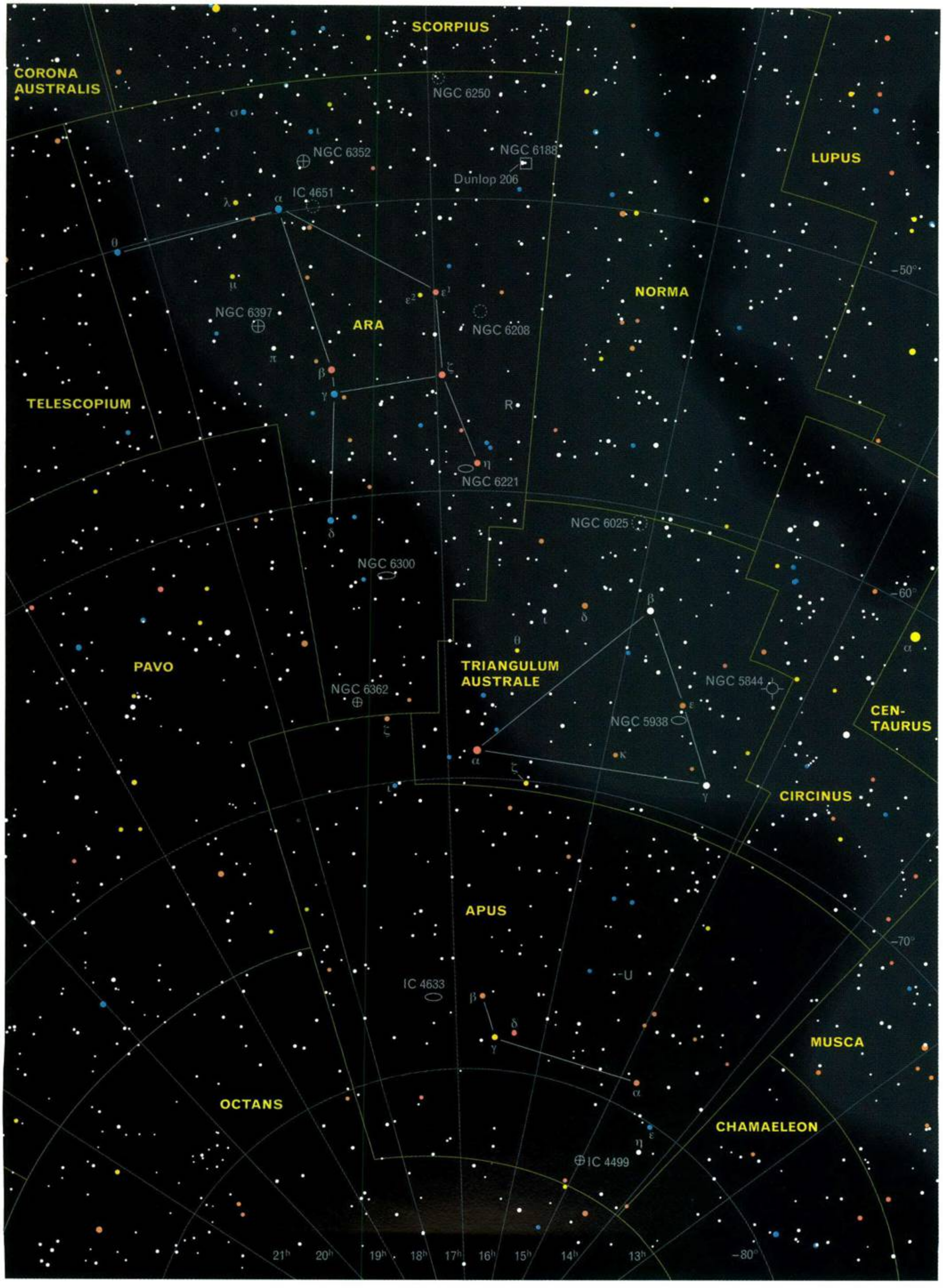
**IC 4499**

Digital Sky Survey/Caltech



**NGC 5844**

Digital Sky Survey/Caltech


SCORPIUS
CORONA AUSTRALIS
NGC 6250
NGC 6352
NGC 6188
Dunlop 206
IC 4651
LUPUS
ARA
NORMA
NGC 6397
NGC 6208
-50°
TELESCOPIUM
R
NGC 6221
NGC 6025
NGC 6300
-60°
PAVO
TRIANGULUM AUSTRALE
NGC 5844
NGC 6362
NGC 5938
CEN-TAURUS
CIRCINUS
-70°
APUS
U
IC 4633
MUSCA
OCTANS
CHAMAELEON
IC 4499
21h
20h
19h
18h
17h
16h
15h
14h
13h
-80°

Digital Sky Survey/Caltech

Move 3° south to find **IC 4651**, a beautiful cluster of scattered stars that looks good in small telescopes. Small binoculars reveal the cluster, which lies 3,000 light-years away, as a condensation in the Milky Way. A 3-inch scope begins to resolve its brightest stars. A magnification of about 50x provides the best view, with the cluster's 50 stars standing out nicely from the surrounding field. Large-aperture telescopes only show the fainter field stars, removing the distinctive, "isolated" appearance of the cluster. Look for a small, prominent clump of bright stars near the center.

As one of the sky's brightest globular clusters, **NGC 6397** would certainly have earned a Messier designation if it were in the northern sky. Easily visible with the naked eye as a fuzzy star in Ara, this globular is only moderately impressive in scopes. A 13-incher shows it as slightly concentrated toward the brighter middle members out to a 15' diameter. While the cluster is one of the sky's brightest, its vivid glow comes only from a small number of bright stars. At higher magnifications, the group resembles an open cluster. Only 8,700 light-years away, NGC 6397 is the second closest globular cluster to us, after M4.

Panning about 3° southwest of Delta Arae brings you to **NGC 6300**, a nearby, ringed, barred spiral galaxy. About 50 million light-years away, its outer ring measures 20,000 light-years in diameter. NGC 6300 appears fairly faint through a 12-inch scope, measuring 4' by 3' and showing a much brighter core. A 13th-magnitude star lies just south of this core. A scope of 17 inches or bigger is needed for a good view of the faint spiral arms.

At the southern border of Ara awaits a faint globular cluster, **NGC 6362**. This elusive cluster lies at the edge of the Milky Way's bulge, 18,000 light-years from its center and 28,000 light-years from the sun. A small telescope easily shows a cluster measuring 5' across with only a slight central concentration. The cluster appears "grainy" due to many unresolved stars. The view improves greatly with a 16-inch scope, wherein countless swarms of stars of magnitudes 14 and 15 comprise an impressive sight. Use high magnifications on dark nights with steady seeing for the most rewarding views of this cluster.

At the northern edge of Triangulum Australe lies a bright object that is ideal for smaller sized telescopes. **NGC 6025** is an open cluster of 50 stars located 3,000 light-years away. In an 8-inch scope, a well-defined group of two dozen stars of magnitudes 9 and 10, spread across 10', appears well. Before moving your scope to the next object, be sure to look for a 7th-magnitude star shining at the southern end of this cluster.

Nudge the scope 1° southeast of the

## Deep-Sky Objects in Triangulum Australe, Apus, and Ara

| Object | R. A. (2000.0) | Dec. | Mag. | Size/Sep./Per. | Type | Notes |
|---|---|---|---|---|---|---|
| IC 4499 | 15h00.3m | –82°13' | 9.4 | 7.6' | GC | |
| NGC 5844 | 15h10.7m | –64°40' | 13.2 | 53" | PN | |
| U Apodis | 15h28.1m | –75°56' | 8.4 | — | Star | Carbon star |
| NGC 5938 | 15h36.4m | –66°52' | 11.7 | 2.7' by 2.4' | Gal | SB(s)bc |
| NGC 6025 | 16h03.7m | –60°30' | 5.1 | 12' | OC | |
| R Arae | 16h39.7m | –57°00' | 6.0–6.9 | 4.425 days | Var | Eclipsing binary |
| NGC 6188 | 16h40.5m | –48°47' | — | 20' by 12' | BN | |
| Dunlop 206 | 16h41.3m | –48°46' | 5.6/6.8 | 9.6" | Dbl | |
| NGC 6208 | 16h49.5m | –53°49' | 7.2 | 12' | OC | |
| NGC 6221 | 16h52.8m | –59°13' | 10.1 | 4.9' by 3.2' | Gal | SAB(rs)bc |
| NGC 6250 | 16h58.0m | –45°57' | 5.9 | 7' | OC | |
| IC 4633 | 17h13.8m | –77°32' | 11.8 | 4.0' by 3.0' | Gal | SAB(r)d |
| NGC 6300 | 17h17.0m | –62°49' | 10.1 | 5.2' by 3.3' | Gal | SB(r)b |
| IC 4651 | 17h24.7m | –49°57' | 6.9 | 12' | OC | |
| NGC 6352 | 17h25.5m | –48°25' | 8.1 | 7.1' | GC | |
| NGC 6362 | 17h31.9m | –67°03' | 7.5 | 10.7' | GC | |
| NGC 6397 | 17h40.7m | –53°40' | 5.8 | 25.7' | GC | |

**Object:** Designation in NGC or other catalog. **R. A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep./Per.:** Size in arcminutes or arcseconds, separation in arcseconds, or period in days. **Notes:** Hubble types for galaxies.

# The Altar

*"Let independence be our boast, Ever mindful what it cost; Ever grateful for the prize, Let its altar reach the skies!"*
Hail, Columbia! *Joseph Hopkinson (1770–1842)*

The southern sky is a treasury of classic mythological stories, overflowing with gods and goddesses, lies and deceit, love and war. But the tale surrounding Ara the Altar is a unique one, as it represents one of the most momentous events in all of Greek mythology — the war between the Olympians and the Titans.

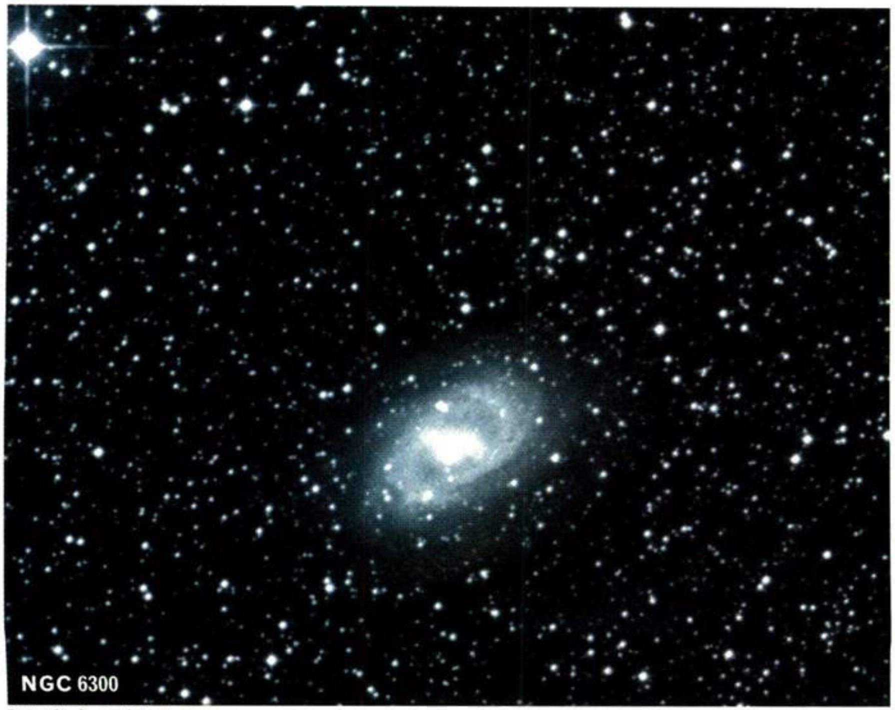
The story begins with Cronus, one of the twelve Titans and ruler of the Universe at the time. After hearing a prophecy that stated one of his sons would overthrow him, Cronus desperately tried to prevent this by swallowing each of his children as they were born. By the time his wife, Rhea, became pregnant for the sixth time, she could not bear to allow another child to meet this fate. So she smuggled the newborn Zeus to the cave of Dicte on the island of Crete, giving Cronus a stone to swallow in the baby's place.

Years later, Zeus returned to his father's palace and forced him to spit out all of his siblings, who emerged as full-grown gods and goddesses. Soon after, Zeus and his brothers constructed an altar, on which they solemnly vowed to overthrow the rule of Cronus and all the Titans.

After 10 years of war, Zeus sneaked down to Tartarus, where Cronus had long ago imprisoned the monstrous brothers of the Titans, the Cyclopes and the Hecatoncheires. The two sets of brothers gladly agreed to help Zeus and the Olympians, in exchange of their freedom, by granting them weapons, including lightning bolts for Zeus. Soon, the Titans were defeated, and the Olympians divided up the powers of the universe, with Zeus earning the rule of the sky. To commemorate their victory eternally, Zeus set the sacred altar in the sky as the constellation Ara. — *Elesa Janke*

5th-magnitude star Eta Circini to find the planetary nebula **NGC 5844**. Long-exposure photographs of the nebula show a planetary with a classic dumbbell form. The view through a large telescope confirms this structure, with two faint lobes in contact, oriented east-west. Because it is quite distant at 4,400 light-years away, NGC 5844 requires a 6-inch or larger telescope and a narrow-band nebula filter to acquire a good view.

About ½° south of Epsilon Trianguli Australis lies the distant spiral galaxy **NGC 5938**. Although a large scope shows it as only a faint smudge 1' across with a brighter center, its great distance of 300 million light-years makes this luminous galaxy a very impressive sight.



NGC 6300

Digital Sky Survey/Caltech

Midway between Alpha and Kappa$^1$ ($\kappa^1$) Apodis awaits one of the sky's reddest stars, **R Apodis**. A deep red carbon star, R Apodis is a cool giant with a sooty atmosphere that reddens its light. At magnitude 8.4, it can be spotted easily using binoculars. Sometimes defocusing stars makes their colors more obvious.

Quite near the South Celestial Pole lies the globular cluster **IC 4499**. At a distance of nearly 60,000 light-years, its brightest stars glow feebly at 15th magnitude. Even in a 12-inch scope, this faint cluster requires dark skies to be seen at all. It appears about 5' across and has little central concentration.

Our southern tour closes with another globular cluster, **NGC 6101**, a small group with stars bright enough to be visible in a 6-inch scope. The cluster appears about 3' across and has a gradual concentration of light toward its center. Use your highest magnification to resolve dozens of equally bright stars. In large scopes, NGC 6101 proves to be a pleasing sight, appearing as a disk nearly 5' across that is strewn with stars.

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*Tom Polakis is an aerospace engineer living in Tempe, Arizona, whose favorite astronomical pursuits are deep-sky observing and photography.*

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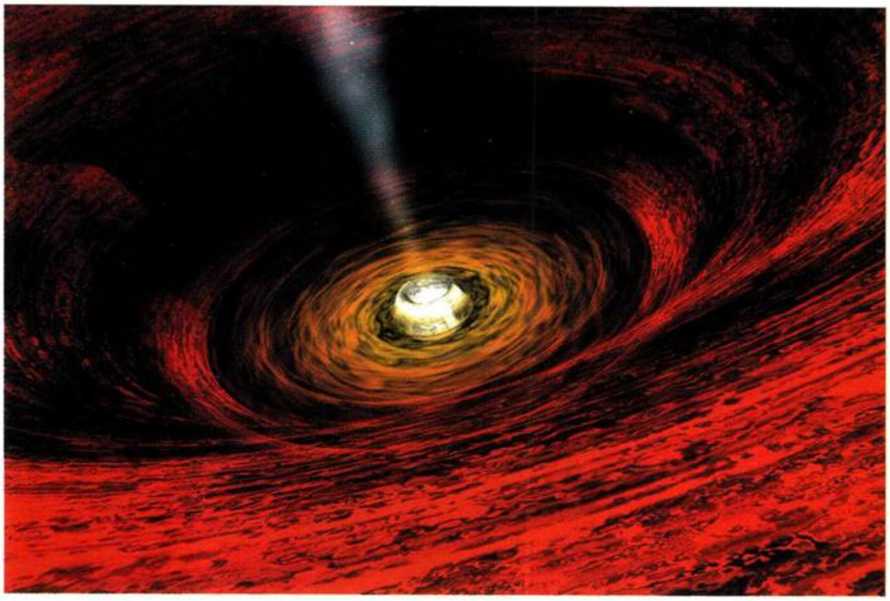
# ask Astro

Bino-Viewing, Fuzzy Pluto, Deep-Sky Highlights



**No small matter. Black hole engines power the brightest lights of the cosmos.** NASA/CXC/A. Hobart

### Was our Milky Way Galaxy once a quasar? — *Barry Albert, Ontario, Canada*

Quasars (short for quasi-stellar radio sources) are the brilliant cores of distant active galaxies. Though they may lie several billion light-years from Earth, quasars shine with a brightness that rivals even nearby stars. Consequently, quasars must be fueled by an extremely energetic source.

After years of research, astronomers have settled upon a likely source of quasar activity — the steady infall of matter onto supermassive black holes inhabiting the cores of active galaxies. As matter is gobbled up by these quasar engines, it swirls around in a disk and heats substantially, releasing energy in the process. For quasars to shine, host galaxies must contain a supermassive black hole — generally believed to possess the mass of a billion suns or more — as well as a sufficient reserve of infall material.

Recent evidence indicates that our galaxy harbors a supermassive black hole at its center. Still, the Milky Way's black hole is believed to be 1,000 times less massive than the typical quasar engine. So even if the Milky Way went through an episode of heavy infall activity billions of years ago, the quantity of matter must have been much less compared to the quasars we observe today. At the peak of activity, our galaxy probably would never have been as bright as what we now observe from quasars. — *Jay M. Pasachoff, Director of Hopkins Observatory and Chair of Astronomy Department, Williams College*

### Why aren't twin scopes or binocular eyepieces more popular in the amateur astronomy market? What benefits/limitations can buyers expect? — *John D. Van Dyke, San Mateo, California*

Whether observing the universe naked-eye or with a telescope, two eyes are much better than one. The reason binocular telescopes and binocular eyepieces have not replaced traditional monocular equipment is that they just aren't practical for most people.

Binocular telescopes are twin telescopes of the same aperture mounted side-by-side. Through sheer design constraints, the eyepieces from each scope are forced to be much farther apart than the interpupilary distance of the observer. To get the eyepieces closer together requires the use of flat mirrors or prisms to fold the path from each telescope toward the middle and then back out to your eyes. Consequently, six extra mirrors eat up some of the incoming photons while adding considerable expense. And because the interpupilary distance varies between individuals, provisions must be made to adjust the whole apparatus for custom viewing.

But perhaps the biggest challenge comes with getting the two images to merge. The focal length of each telescope must be exactly the same and they must be perfectly collimated with each other. With all these engineering and cost concerns, you can see why binocular telescopes aren't too practical for most folks.

The binocular viewer (or bino-viewer), however, remains an attractive alternative. These have been around for many years and in general work quite well with only a few limitations. A bino-viewer is inserted into the focuser and accepts the incoming light from your telescope. There it divides the beam of light, using prisms to send half of the light to each eye.

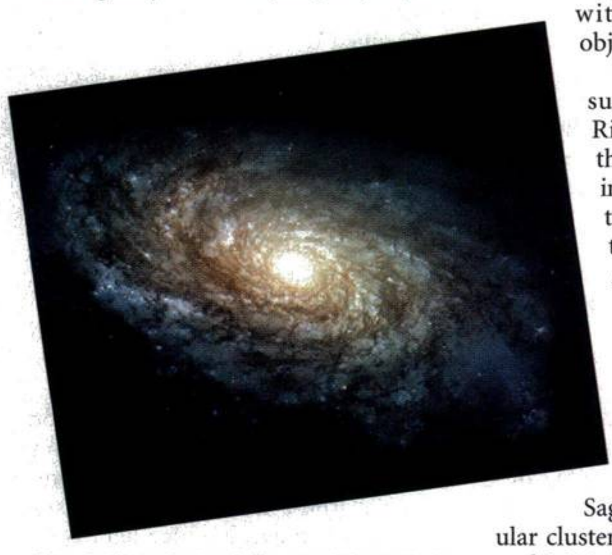
Unlike binoculars, which use a separate objective lens for each eye, a bino-viewer is limited by a single lens or mirror on your telescope. This means that the images you see are only half as bright as they would be with a traditional monocular eyepiece. And to make matters worse, the prisms in bino-viewers absorb some light as well. This presents a distinct disadvantage for deep-sky observing. Your retina needs all the photons it can get when viewing dim objects like galaxies. For faint deep-sky objects, bino-viewers don't deliver.

The upside is that a bino-viewer will afford amazing views of the moon and planets, or very bright deep-sky objects like globular clusters or the Orion Nebula. If you can handle the expense of a good bino-viewer and the two sets of eyepieces to go with, you'll never go back to monocular viewing for bright objects. — *Dave Kriege, Obsession Telescopes, www.obsessiontelescopes.com*

### Why can the Hubble Space Telescope only capture fuzzy images of Pluto, yet produce crystal-clear images of objects light-years away? — *George Peer, Ontario, Canada*

You might think that something close should be easier to see than something far away, but that isn't always the case. A tiny snowflake falling a few feet away might be nearly invisible, while a mountain ten miles in the distance stands out clearly.

The same is true for astronomical objects. Pluto is literally billions of times closer to Earth than the nearest galaxies. But galaxies are big: Pluto is only about 1,400 miles across. Even a small galaxy can be 10,000,000,000,000 times bigger than Pluto. That makes these distant mountainous galaxies easier to see than a frozen snowball-like Pluto in our own backyard.



**Star clusters stand out like mountain peaks in the arms of NGC 4414 — 60 million light-years away.** Hubble Heritage Team(AURA/STScI/NASA)

And remember, the detail we see in galaxies looks small only when compared to the galaxies themselves. Even these "tiny" features are much larger than the solar system. — *Phil Plait, webmaster, www.badastronomy.com*

**Get ready for summer: Feast your hungry eyes on the Lagoon Nebula (M8) and its southern celestial neighbors.** Tony Hallas

### I recently bought a 6-inch Dobsonian telescope to observe deep-sky objects. What are your recommendations for a deep-sky novice like myself? — *Matty Hellard, Chicago, Illinois*

The answer depends on the time of year you're observing. But with a 6-inch Dobsonian, the entire Messier catalog comes into view, along with some very nice NGC objects and double stars.

Some of my favorite summer objects include the Ring Nebula (M57) in Lyra, the Dumbbell Nebula (M27) in Vulpecula (which is harder to find than the Ring), and the gorgeous double star Albireo at the head of Cygnus (check out the color contrast). Don't miss the glorious globular cluster M13 in Hercules. And if you have an unobstructed southern horizon, check out these gems in Sagittarius and Scorpius: globular clusters M4 (just west of Antares) and M22 (at the top of Sagittarius's teapot), and the following star-forming regions: the Swan (or Omega) Nebula (M17), the Eagle Nebula (M16), the Lagoon Nebula (M8), and the Trifid Nebula (M20).

In autumn, don't miss the Andromeda Galaxy (M31). See if you can spot its two fainter companion galaxies, M32 and NGC 205. Also look for a beautiful gold and blue double star nearby, called Gamma Andromedae. M15 in Pegasus is one of my favorite globular clusters. The famed Double Cluster (NGC 869 and NGC 884), which lies southeast of Cassiopeia, can be seen any time of year, but is highest in the sky in autumn.

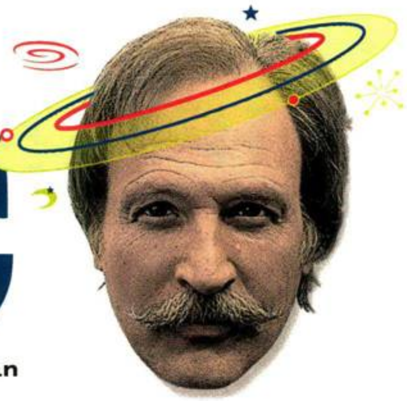
The Orion Nebula (M42) is the crown jewel of the winter sky, plus it's a piece of cake to find. Look at the Pleiades (M45) through a wide-field eyepiece to get the whole cluster. Another nice open cluster is M41 in Canis Major near Sirius.

In the spring, just sweep through Virgo and you can't help but see a multitude of faint, fuzzy galaxies belonging to the great Virgo Cluster. Of these, my favorite is the Sombrero Galaxy (M104) because of its thick dust lane, which should be easily visible from a dark site. The Beehive Cluster (M44) in Cancer is also beautiful, but like the Pleiades, it's probably best seen with binoculars. The Whirlpool Galaxy (M51) is a beautiful face-on spiral near the tail of the Big Dipper. You'll see M51's nucleus and a companion galaxy, but you will need to observe from a very dark area if you want to make out the spiral arms. Enjoy. — *Robert Naeye, Astronomical Society of the Pacific*

**CONTACT INFO**

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53187. Please tell us your full name and where you live.

# strange Universe



by Bob Berman

## Muggy Marvels

A woman I know revels in hot muggy weather, cheerfully running to her garden when everyone else seeks air-conditioned refuge. But such eccentrics aside, few find humidity exhilarating — yet backyard astronomers must learn to love humidity and cope with its symptoms during the long hot months of summer.

In a western swath that includes Idaho and Montana, July is heaven. There, residents are justifiably proud of the wonderfully dry air. And the Southwest's broiling summer days transform into pleasantly arid nights that combine with that region's clear open skies to deliver some of the country's best skygazing.

But for most of us, mugginess is a frequent unwelcome summer visitor. Lenses fog up, all but the brightest stars vanish behind a hazy veil, meteors play hard to get, and observing the Milky Way Galaxy becomes an impossible feat. Worse, night's cool-down often brings air to its saturation point, raising humidity to the hundred percent that creates fog or mist.

For all that, muggy air also offers some surprising benefits. Like any foe, it can often be tamed by being understood.

Water vapor surprises most people. Nearly everyone perceives it as something dense, and it certainly feels "close" when perceptible moisture brushes against skin, giving us expressions like "fog as thick as pea soup."

But fog is not thick. To the contrary, the higher the humidity, the thinner the air is. A cubic foot of moist foggy air weighs less than the same volume of dry clear air. That's why airplanes require longer runways when it's humid. Their take-off rolls can be as much as 10 percent longer and they need more speed and distance to clear the same obstacle simply because less substance is running over and under their wings to supply lift.

This seems counterintuitive, but it makes perfect sense. Water vapor is $H_20$, which is two-thirds hydrogen, the lightest element. Each molecule of $H_20$ means a bit less of everything else, like the much heavier nitrogen that constitutes most of the atmosphere. Moreover, warmer air can hold far more water than cool air, so that July (the hottest month in most of the Northern Hemisphere) provides the wettest possible atmosphere.

The temperature factor is enormous. Each cubic foot of 90° air can hold 30 times more water vapor than it can at 0°. The backyard astronomer on a summer night is like a fish, peering upward through tons of water.

The first way humidity affects skywatchers is in cloud production. The process is easily demonstrated by breathing on a mirror. Cool glass instantly chills humid breath to a temperature incapable of carrying that much moisture, which then immediately condenses into a foggy film.

Outdoors, a similar thing happens. July's fierce sunlight warms the ground, which heats the air just above it; this air then rises because warm air is less dense. As it ascends, the mass of rising air cools dramatically at the rate of 5.5° per thousand feet, until it can no longer hold its moisture, which then abruptly condenses into droplets: A cloud is born. That's why clouds hover so picturesquely at the same height. Their flat bases reveal the altitude (typically three to eight thousand feet) at which it's cool enough so that the rising air can no longer carry its vapor.

Because moist air reaches saturation more easily, humid air doesn't have to rise as much to become a cloud. Clouds are therefore lower and more numerous whenever the air is sticky. Armed with this knowledge, you can predict ahead of time whether to expect morning's clear conditions to metamorphose into afternoon clouds that may linger to ruin your planned observing session.

Clouds appear white because their tiny water droplets reflect all of the sun's wavelengths equally. In winter, clouds in most of the U.S. and Canada tend to be sheets of overcast, while now in summer, local ground heating often yields scattered puffy cumulus clouds that sit in sunlight. And so what? Just this: Isolated clouds basking in sunlight display a pure white that precisely matches a G0 spectral class star.

If you've ever wondered why high-altitude balloonists and astronauts say that the sun is snow-white, yet it looks lemony to us mortals on the ground, it's because the sun's blue component gets scattered away en route to our eyes. Bouncing like billiards among atmospheric molecules, blue light is six times more prone to scattering than other colors, giving the sky that hue. But we didn't get the blue sky for free. This blue has been subtracted and removed from incoming sunlight. Since the sun's actual white minus some of its blue constituent yields a yellowish tint, we never view the true appearance of our spectral class G0 companion star when looking at it directly.

But when we observe a *cloud floating in* a blue sky, it reflects the sky's blue light as well as sunlight. The two colors recombine. With the blue now restored, the cloud reveals the true appearance of the sun, with the false yellow tint erased.

Many amateurs believe that spectral class G (the sun's type) denotes a yellow star. Wrong. Type G is a transition class, whose early examples (G0 or G1) are as white as Cinderella's dress. Only in the late Gs (G8 or G9) do stars start taking on the yellowish cast of the pages of a faded paperback.

While haze or moisture in the form of clouds serve as a "platinum bar" to calibrate the spectral sequence by demonstrating the sun's true color, humidity also helps astronomers by stabilizing air temperature. Moist muggy nights are associated with uniform atmospheric layers; air does not cool below its dew point. Instead of a rapid, chaotic temperature drop with blur-inducing pockets of warm or cold air, humid nights typically boast homogeneous temperatures.

True, such haze greatly diminishes the clarity of the atmosphere and makes deep-space objects hard to observe. But it also steadies the seeing and sharpens telescopic images. Result: dimmer but better-defined viewing. Planets such as Mars, now so bright in the south all night long, typically yield far more detail on muggy nights than on dry ones.

For objects such as the moon with high surface brightness, a humid night often opens a portal for observing breathtakingly fine features through the eyepiece. It is also one of the best times to observe otherwise hard-to-resolve components of double stars. These can finally be seen — provided the challenge lies in their close separation rather than in their faintness.

In short, just as coaches make playcards for almost every football situation, backyard astronomers should create mental "target lists" that specifically exploit the exquisite and extraordinary opportunities presented on hazy nights.

So, as in most things in life, humidity isn't entirely a bad thing. On muggy nights, just grab a dew-covered eyepiece, give it a quick wipe with your clean cotton shirt, and you'll find that some of the finest telescopic objects are no sweat. ■

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*Bob Berman produces* Strange Universe *for nearly every issue of* Astronomy *magazine. He is the author of several astronomy books, including* Secrets of the Night Sky.

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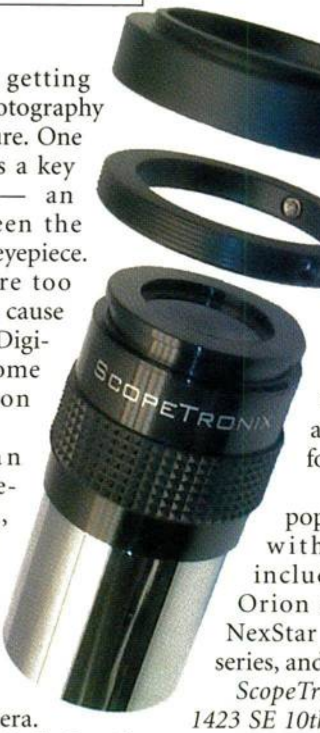
Photographers can simply remove their eyepiece's rubber eyeguard, slip the Digi-T (middle threaded ring) into the empty eyeguard slot, and secure it with three setscrews. The proper step ring (top) then couples the Digi-T to the camera. Once installed, the Digi-T is flush with the end of the eyepiece and ready to accept a digital camera. The eyepiece lens and the camera lens must fit together as closely as possible, as a separation of even 0.5" will result in an image that looks as if it was taken through a soda straw. Digi-T doesn't raise the eyepiece up in its holder, which is an advantage to telescope users who cannot focus with conventional adapters due to limited focus range.



The Digi-T fits most popular 1.25" Plössl eyepieces with rubber eye-guards, including the Meade 4000, Orion Sirius Plössl, Celestron NexStar Plössl, Scope Tronix ST series, and many others.

*ScopeTronix Astronomy Products, 1423 SE 10th St., Unit 1A, Cape Coral, FL 33990; phone, (941) 945-6763; e-mail, info@scopetronix.com; website, http://www.scopetronix.com. $59.95 to $89.95, depending on camera model (plus shipping).*

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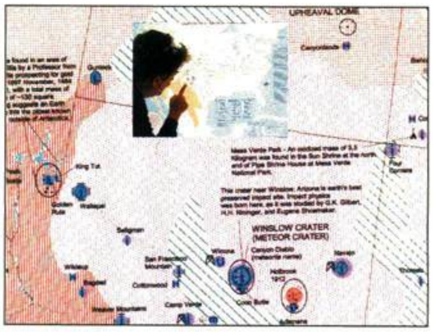
*Bill and Janie Peck, Box 771559, Steamboat Springs, CO 80477; phone, (970) 879-3621; e-mail, bpeck@meteoritemaps.com; website, http://www.meteoritemaps.com. $25 (plus applicable taxes and $5 shipping).*



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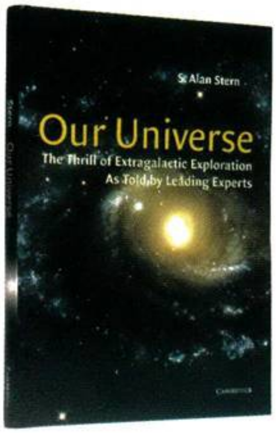
## BOOKS

### Our Universe: The Magnetism and Thrill of Extragalactic Exploration

Edited by S. Alan Stern, 483 pages, Cambridge Univ. Press, New York, 2001; ISBN 0-521-78330-5, hardcover, $54.95; ISBN 0-521-78907-9, paperback, $19.95

Scientists' giant steps forward are often viewed as stemming from moments of sheer inspiration. Archimedes's famous cry of "Eureka!" as water ran over his bathtub when he plunged in provides the stereotypical reasoning that the public imagines is behind the great discoveries. Stern, of the Southwest Research Institute in Boulder, Colorado, has compiled nine stories to help set the record of discoveries straight. *Our Universe: The Magnetism and Thrill of Extragalactic Exploration*, is a fascinating collection of writings by cosmologists who testify to the years of effort that paved the way for their epochal revelations.

For instance, Greg Bothun of the University of Oregon (a.k.a. "Dr. Dark Matter") spent a decade of his life pursuing ghosts: the notion that most galaxies in the universe may be so dim and diffuse as to have eluded detection. Painstaking efforts at chasing hidden evidence for virtually invisible matter were eventually crowned with success. The breakthrough came with the detection of interstellar gas — glowing at a radio wavelength of 21cm — that revealed the presence of vast amounts of mass in the form of dimly gleaming stars. The Doppler shift of the radio line emission enabled measurement of the stars' masses.


S. Alan Stern
Our Universe
The Thrill of Extragalactic Exploration
As Told by Leading Experts

And we may just be viewing the tips of galactic icebergs. Feebly shining collections of stars may outnumber the luminous galaxies such as our nearest neighbor, the spiral in Andromeda. Gamma-ray bursts are common in the universe — a realization that was the epochal culmination of a vigorous debate that began when flashes of gamma rays in the sky were first discovered by Soviet and U.S. satellites searching for any evidence of thermonuclear explosions in space. Orbiting gamma-ray telescopes discovered tens of bursts, yet did not succeed in localizing them sufficiently for

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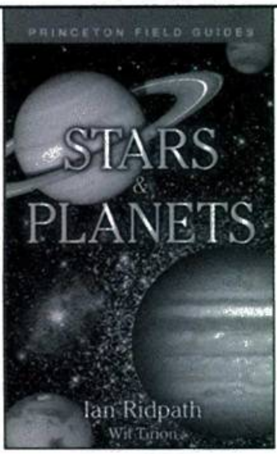

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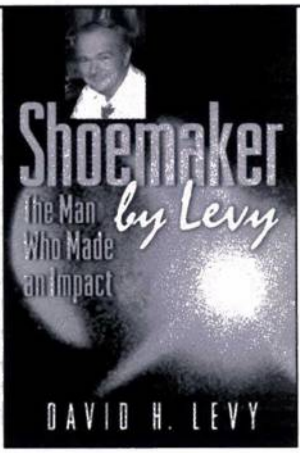

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astronomers to observe them with optical telescopes and thereby determine their distances from Earth.

Most astronomers could not stomach the idea that cosmic explosions of unprecedented energy occurred daily in the remote depths of the universe. They maintained that gamma-ray bursts were a local phenomenon, occurring within a hundred parsecs of the sun. Polish astronomer Bohdan Paczynski, now at Princeton University, took the view that the isotropy of the sources logically meant that they were located at cosmological distances. Never mind that one had to trump supernovae to do so. Paczynski coined the phrase "hypernovae" to describe gamma-ray-burst sources that explode with the luminosity of about one hundred billion suns.

In September 1991, Astronomer Royal Sir Martin Rees gave Paczynski 100 to 1 odds that the bursts were not extragalactic. Two weeks later, the BATSE (Burst and Transient Source Experiment) from the Compton Gamma Ray Observatory satellite reported hundreds of bursts throughout the sky. Yet the astronomical community remained divided on the remote origin of these bursts and hence their nature. Not until 1995 was the problem resolved, when the Italian BeppoSAX x-ray satellite pinpointed the burst locations.

Astronomers trained powerful terrestrial telescopes in the precise directions of the gamma-ray bursts, and found fading star-like objects often embedded in host galaxies at the far ends of the visible universe. Paczynski's vision of hypernovae was seemingly validated. Rees remarked of their established bet, "We were both fools: I for offering the bet; [Paczynski] for not accepting it."

Even this did not mark the end of the story. In 1999, one of the most intense gamma-ray bursts ever recorded almost simultaneously emitted an optical flash. For a few seconds this object attained 9th magnitude, bright enough to be visible with binoculars, despite being about 10 billion light-years away. Studies of the optical afterglow have turned the tide again; strong evidence exists that the gamma rays are beamed, so that the true lumi-

## The Webweaver Picks

The June 21 eclipse is the first total solar eclipse of the millennium, with the path of totality starting in the South Atlantic and sweeping across Africa before ending in the Indian Ocean. Webweaver found help for the eclipse enthusiasts stuck in other continents.

**Africlipse** (http://www.eclipse.za.net) is a nicely designed site that has everything from charts and road maps to totality tables for towns and cities, and safari tips. For a webcast, try **SolarEclipseAfrica** (http://www.solareclipseafrica.com/) or **Exploratorium** (http://www.exploratorium.edu/eclipse/), which will link to Space Station astronauts and show the moon's shadow cross Earth.

2001 June 21
The Total Solar Eclipse of 2001 June 21
ECLIPSE
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Bill Kramer, the webmaster of **Eclipse Chasers** (http://www.eclipse-chasers.com) offers his images, recollections, articles on eclipse watching and photography, plus a link to Robin Edgar's **Treasures of Darkness** (http://homepage.altavista.com/treasures/files/treasures2.html), a site detailing the effects of eclipses on ancient cultures.

**Dan McGlaun** (http://www.mcglaun.com/eclipses.htm) has created a humorous page detailing commemorative eclipse stamps.

The **Eclipse Café** (http://www.sky-rover.net/eclipsecafe) is always open. This stylish site allows chasers to exchange ideas and experiences.

Not all pioneers of modern astronomy are revered, which is why it's nice to acknowledge **Maria Mitchell** (http://vassun.vassar.edu/~physastr/mariamitchell/), an early eclipse chaser and astronomer. The site describes Mitchell's accomplishments and encourages students to become virtual eclipse chasers. School groups interested in joining the virtual experience must register and plan their expeditions as though they were actually in Africa. Team reports will be posted on the site.

Eclipse Expedition 2001

**Professor Parkinson's Eclipse Website** (http://www.shu.ac.uk/eclipse/) is designed for adults. The Director of Science and Mathematics at Sheffield Hallam University, England, Parkinson explains eclipses in understandable detail and provides information on how, when, and where to observe the African event.

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Planetariums, museums, and colleges can broadcast via the **Museum Eclipse 2001** (http://www.museumeclipse.org/) site.

Many of these sites owe a debt to **Fred Espenak** (http://sunearth.gsfc.nasa.gov/eclipse/). Some people call him the godfather of modern eclipse astronomy. — *Richard J. Bartlett* nosity is no more than that of an ordinary supernova — no need after all for superbright hypernovae.

Other astronomical warriors who have battled for years to validate their views tell their stories in *Our Universe.* John Huchra battled with observatory directors and funding agencies to build and exploit a redshift machine, with which he charted the universe. John Mather, fresh out of graduate school, went to work for the COBE (Cosmic Background Explorer) satellite experiment where he toiled for 16 years before producing the first precise measurements of the cosmic microwave background radiation, the remains of the primeval fireball from which the universe was created. When he first revealed the blackbody spectrum to an auditorium packed with a thousand astronomers in 1990, he said very little — he simply projected the smoothly curving plot on a screen. Everyone present instantly knew that the theoretical prediction of a hot, dense beginning to the universe had been magnificently verified. Mather received a standing ovation.

Astronomy can be a lonely pursuit. But there is more to it than the solitary observer toiling all night on a remote mountaintop. There is vision modulated by empirical reasoning or theoretical prejudice, and there is implementation, characterized by unremitting effort that can lead to — but by no means invariably to — major breakthroughs in the frontiers of our knowledge of the universe. *Our Universe* describes some of the major success stories. It is sobering to note that a book on the failures would be far longer. — *Joseph Silk, University of Oxford, United Kingdom*

### Kepler's Philosophy and the New Astronomy

Rhonda Martens, 201 pages, Princeton University Press, Princeton, New Jersey, 2000; ISBN 0-691-05069-4; hardcover, $37.50.

Johannes Kepler published in many fields — astronomy, of course, but also optics, mathematics, astrology, music theory, theology, historical chronology, poetry, and even science fiction. However, he never wrote about what is now termed philosophy. Nevertheless, Rhonda Martens shows in this historically informed tome that Kepler grappled constantly, and advantageously,

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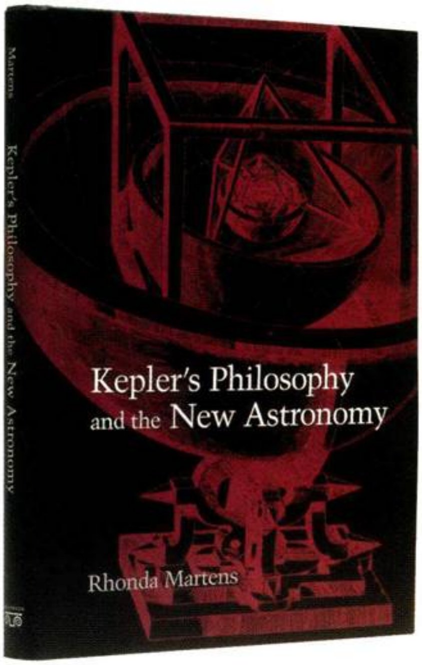
Kepler's Philosophy and the New Astronomy
Rhonda Martens
Martens
Kepler's Philosophy and the New Astronomy

with philosophical problems throughout his career.

*Kepler's Philosophy and the New Astronomy* is the first book-length study to address directly the fundamental philosophical problem with Kepler — his use of archetypes in his scientific work. Archetypes, which Martens aptly describes as "divine aesthetics," are a deliberate intrusion of philosophy and theology into science. They are difficult for us to understand today; therefore, most historians politely ignore them.

Yet Kepler, seeking to understand the natural world, embraced archetypes. They brought a priori aesthetic principles into the sciences of nature, as guides to be relied upon when empirical evidence was lacking. They were not Kepler's innovations — Aristotle's "formal cause" was essentially an archetype — but his investigations of nature gave archetypes a more quantitative role than his predecessors had given them. Martens's study is therefore most welcome.

The book begins with an overview of Kepler's life and times, followed by a survey of the precocious *Cosmographic Mystery*, the thoughtfully polemical *Defense of Tycho against Ursus*, and the astoundingly original "New" astronomy. Subsequent chapters treat "The Aristotelian Kepler" and his later works *Harmony of the World* and *Epitome of*

*Copernican Astronomy*. It's evident that Martens's philosophy of science is thoroughly grounded in history. Throughout she shows a command of Kepler's purely scientific accomplishments, while adroitly highlighting the ways in which his philosophical attitudes guided his scientific work.

Despite the popular view of Kepler as a Platonist, he was educated in the Aristotelian environment of 16th-century Lutheran Germany, and he expressed many of his philosophical ideas in Aristotelian language. His reform of astronomy was based on the introduction of physical arguments that today seem like good ideas, but which in 1600 were suspect because they mixed disciplines. Martens explains that Kepler could not have defended Copernicus without mixing disciplines, and the manner in which he did so was legitimate in an Aristotelian context. Because there was little empirical evidence for heliocentricism, Kepler went beyond traditional astronomy to methodological, physical, or aesthetic principles: He had to mix disciplines, in other words.

The truly original contribution of *Kepler's Philosophy and the New Astronomy* is the tracing of Kepler's philosophical ideas as they weave through and strengthen his science. His metaphysics existed not for its own sake, but as an aid in doing other things. The direct influence of that metaphysics is found not in subsequent philosophy, as such, but rather in new fields of research such as physical astronomy, which Kepler created, and which he was able to justify with his metaphysics. — *Bruce Stephenson, Director of the History of Astronomy Department, Adler Planetarium and Astronomy Museum* ▣

**PRODUCT INFO**

Suppliers should send announcements and color photographs to Star Stuff, P.O. Box 1612, Waukesha, WI 53187, or e-mail starstuff@ astronomy.com. *Astronomy* assumes no responsibility for the product information supplied by manufacturers. Prices are retail and subject to change without notice. Check *Astronomy*'s website for further product updates — http://www.astronomy.com

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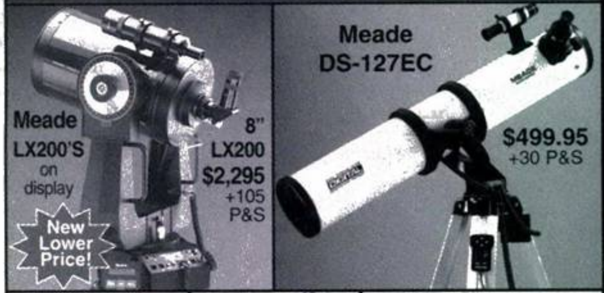

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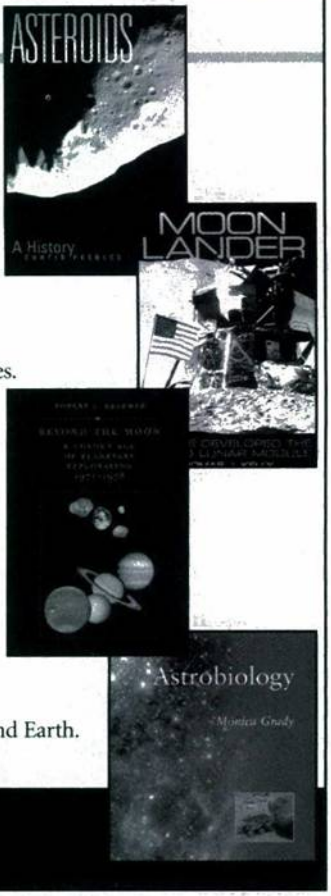

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We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs . . . *and your budget* . . . from the many Meade, Celestron, TeleVue, Takahashi, and Questar telescopes we stock at discount prices from $99 to $27,995.

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We've been shipping LX90 scopes to delighted customers for months (we had 33 in stock as this was written), so the chances are very good you can get an LX90 with little or no delay. While backorders *are* possible on this hot new scope, if Meade is shipping the LX90 for a dealer to keep in stock, chances are good we *have* it in stock.

Meade prices are about the same anywhere you call. So why order a Meade scope or accessory from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade you want . . . right now . . . at the right price . . . right here at ***astronomics.***

## We buy telescopes by the ton . . . literally!

The day before this copy was written, we received 305 cartons from Meade – *3¼ tons* of scopes and accessories in one shipment. Earlier in the same week, we received 9791 pounds of Celestron scopes and accessories in a single shipment – 21 pallets, a full trailer load. We don't know of many dealers – if any – who stock Celestron and Meade products in those quantities . . . *no matter what they claim.* But we do. Telescopes, eyepieces, filters, CCD cameras and autoguiders, dew caps, Barlows, off-axis guiders, illuminated reticle eyepieces, electric focusers, T-adapters, tele-extenders, counterweights – we keep them all in stock.

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And now this Meade is an even better buy! For a limited time, not only has its price been cut by $50, but you get a $99.95 retail adjustable height tripod as a free bonus when you buy!

## We stock Pentax XL eyepieces from $227$^{50}$.

From 5.2mm to 40mm, we stock all the Pentax wide field (55° to 65°) XL eyepieces. Each has a rotate-to-adjust-the-eye-relief eyecup, ED glass, and a long 20mm eye relief that's perfect for those who wear eyeglasses.

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> I have never written to a company about a product that I have purchased, but I feel compelled to tell you how happy I am with the refractor I purchased from you last fall.
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> I just wanted to say thank you, because I would not have this scope were it not for your obvious buying power being passed on to your customers. This is a scope that will provide myself and my family years of pleasure. My 8 year old has become enamored with astronomy now because, since I acquired this scope, it doesn't involve hauling a 100 lb. scope out in the country.
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See our website for full details on this amazing telescope.

**$2999**

## New lower prices on big SBIG CCD cameras!

SBIG has just brought out four new versions of the **ST-8E** 1534 x 1020 pixel enhanced blue sensitivity *self-guiding* two-chip imager (shown above). They've reduced prices on the ST-8E and ST-7E as well!

You can choose from three levels of chip cosmetics with the ST-8E, depending on your budget and imaging needs. Each chip level is available either with or without antiblooming, as you prefer. For spectroscopy, photometry, and critical imaging applications, Class 1 chips have no column or point defects.

The Class 2 versions have no column defects and a very limited number of point and cluster defects. This spec is actually an upgrade of the former ST-8E, at a price that's $1355 lower than the previous models! The Class 2 versions are designed for most scientific applications and excellent imaging.

The entry level Class 3 chip allows for some column, point, and cluster defects, but these can be eliminated by software for very good astronomical imaging at a price that's $1500 below competitive cameras with a similar size chip (although at the expense of restricted scientific applications).

We stock almost all available models of the Apogee LISÄÄ, Meade Pictor, and SBIG CCD cameras, self-guiding cameras, and autoguiders. We also carry a wide range of CCD accessories, as well – flip mirror systems, off-axis guiders, color filter wheels, image processing software, and more. Our large inventory means that the chances are good you won't have to wait to get the camera or accessory of your choice. Here are the SBIG cameras we normally keep in stock and their prices.

| | |
|---|---|
| **SBIG ST-5C** track/accumulate camera | **$895^{00}$** |
| **SBIG ST-237** track/accumulate camera | **$1195^{00}$** |
| **SBIG ST-7E** self-guiding camera | **$2650^{00}$** |
| **SBIG ST-8E** self-guiding camera, Class 1 | **$7350^{00}$** |
| **SBIG ST-8E** self-guiding camera, Class 2 | **$5995^{00}$** |
| **SBIG ST-8E** self-guiding camera, Class 3 | **$4995^{00}$** |
| **SBIG ST-9E** self-guiding camera | **$3950^{00}$** |
| **SBIG ST-10E** self-guiding camera | **$7695^{00}$** |
| **SBIG STV** digital video camera/guider | **$1595^{00}$** |
| **SBIG STVD** digital video w/LCD screen | **$1995^{00}$** |

## TeleVue? We keep it in stock . . . including all the new basic optical tube versions!

TeleVue TV-85, in stock

Hardly a week goes by that TeleVue doesn't send us warranty cards filled with glowing comments written by our customers about the TeleVue scopes they bought from us. But you expect those kind of comments when you sell TeleVue . . . because great products deserve high praise.

TeleVue has added some new products to their scope line, such as optical tube only versions of the **TV-85**, **Ranger,** and **Pronto**. These optical tubes come with a case, but without eyepiece or diagonal, allowing you to upgrade to superb TeleVue optics while using your existing eyepieces and diagonal. There's also a new version of the **TV-102** that now includes a 2" Everbrite diagonal, tube ring, and eyepiece.

All TeleVue scopes are built to the same uncompromisingly high optical and mechanical standards. Their short focal lengths give you an observing flexibility many other scopes lack. Each has the ability to go from very low power wide angle views (as low as 9x in some cases, with a wide 5.7° field) to very high power, all without losing optical quality (one test report said they used an amazing 89x per inch of aperture on the Ranger, TeleVue's least expensive model).

In addition to telescopes, we stock TeleVue eyepieces; Barlows; camera adapters; mounts; Starbeam and Qwik-Point finders; and all other accessories in depth. If it's a product that comes from TeleVue, the chances are good we have it in stock for immediate shipment.

TeleVue eyepieces, all models in stock

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Takahashi FSQ-106N OTA (4" f/5), **$3475**, on an EM-2 mount, **$2229**. Also shown is the FS-102 4" f/8 OTA, **$2349** w/o finderscope.

Why wait for 1-3 *years* to get your apo refractor or mount from another manufacturer? You can usually be viewing through a superb Takahashi apo only a few short days after you order from us. We can also special order larger scopes with 1-3 month delivery times.

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Takahashi FCL-90 ***Sky 90*** OTA (3.5" f/5.6), shown with dew shield retracted, **$2279**

A very hot Takahashi is the unique **FCL-90 *Sky 90*** 90mm f/5.6 refractor. With its self-storing dew shield retracted, as shown above, this remarkable telescope is less than 14" long! It makes a great traveller scope that you can stow away anywhere – *and it's available!*

We also stock the 22" long Takahashi **FSQ-106N** 4" 4-element f/5 dual fluorite astrograph apo refractor OTA. It's another great travelling scope.

If you want premium optics, and you want them *now,* the first name you should think of is Takahashi. The second name should be . . . ***astronomics***.

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## An 8" go-to for only $1499? Amazing!

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NexStar 8

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You now get a $149 retail NexStar adjustable height aluminum tripod and wedge *for free* when you buy a **Celestron NexStar 5** go-to 5" Schmidt-Cassegrain. Not only do you get a free tripod, but its $1149 price is Celestron's lowest ever for a 5" go-to scope!

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**Universe 2001**, the **Annual Meeting of the Astronomical Society of the Pacific**, is coming to St. Paul, Minnesota, **July 13 through 18**. Co-sponsored by *Astronomy* magazine along with **Astronomy.com**, the meeting will feature a star party Friday, July 13, hosted by the Minnesota Astronomical Society, exhibits, speakers, CCD workshops with former *Astronomy* editor Richard Berry, teachers' workshops, award presentations, and more. For information, contact the Conference Coordinator, ASP, 390 Ashton Avenue, San Francisco, CA 94112-1722; (415) 337–1100 ext. 109; e-mail, meeting@aspsky.org; website, http://www.aspsky.org/meetings.html.

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Adler Planetarium and Astronomy Museum, Chicago, Illinois. 5–10 P.M. Telescope viewing, unlimited shows in the Sky Theater and StarRider Theater, lectures by Adler astronomers, and more. Contact (312) 922–STAR; website, http://www.adlerplanetarium.org.

**JULY 15–20**

### Nebraska Star Party

Merritt Reservoir, Valentine, Nebraska. Contact the Prairie Astronomy Club, NSP, c/o Eric Balcom, P.O. Box 540307, Omaha, NE 68154-0307; Hotline, (402) 489–8197; e-mail, NSP@4w.com; website, http://www.nebraskastarparty.org.

**JULY 16–AUGUST 6**

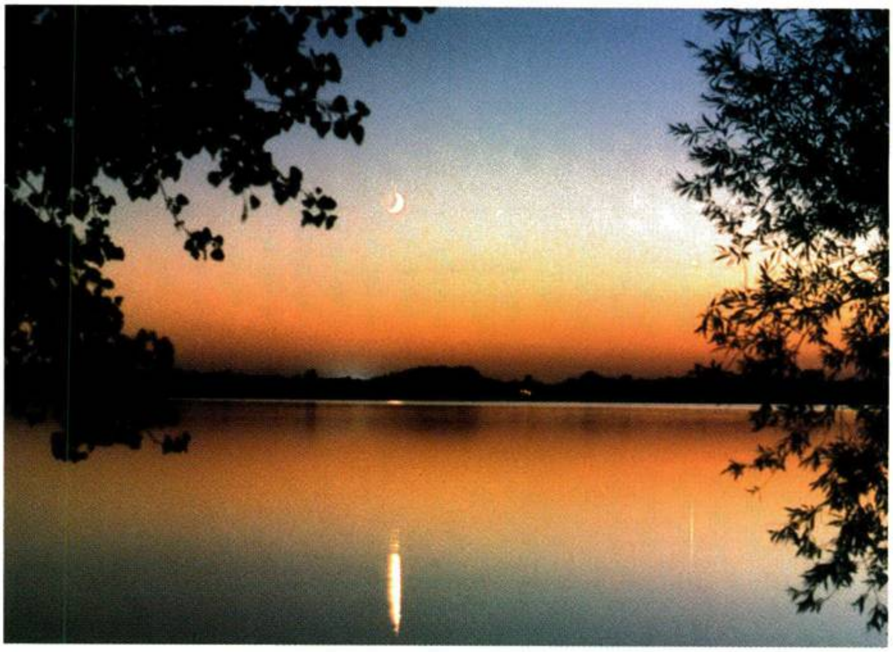
### International Astronomical Youth Camp (IAYC 2001)

Tolmin, Slovenia. Three-week-long international camp for youth between the ages of 16 and 24 able to communicate in English. For information, contact IWAe.V., c/o Kai Dierkes, Pfalzburger Str. 29, 10717 Berlin, Germany; phone, 49–39–8611506; e-mail, kai@iayc.org; website, http://www. iayc.org/2001.

**JULY 8–22**

### Lakes in the Green Star Party

Lakes in the Green, Glennie, Michigan. Sponsored by Eyes on the Sky astronomy club. For more information, contact Edward Conley, 690 North Lake Pleasant Road, Attica, MI 48412; e-mail, edwardrconley@space.com.



Dennis Zerwas, Jr.

Reflections of the crescent moon and Venus add to the tranquility of this mid-summer's eve.

**JULY 20–22**

### Arkansas Star Party

Devils Den State Park, West Fork, Arkansas. Sponsored by the Arkansas-Oklahoma Astronomical Society, P.O. Box 31, Fort Smith, AR 72902-0031; website, http://www.aoas.org.

**JULY 20–22**

### The Conjunction

Northfield Mountain Environmental Center, Northfield, Massachusetts. Contact Jack Megas, 311 Surrey Road, Springfield, MA 01118; e-mail, rsanderson@juno.com.

**JULY 20–22**

### Gateway to the Universe Star Party

Monro Family Campground, Powassan, Ontario, Canada. Sponsored by the North Bay Astronomy Club. A private, non-electrical camping area is provided for all participants adjacent to a family campground with electricity and beach. Guest speakers, commercial display, swap table, food on site. For more information and brochure, contact Tom Ouellette, (705) 474–7666, or Merlin Clayton, (705) 472–1182; e-mail, galaxy@efni.com.

**JULY 20–22**

### RocheStar Fest

Lewis S. Wolk Observatory, Ionia, New York. Sponsored by the Astronomy Section of the Rochester Academy of Science. Contact ASRAS at P.O. Box 20292, Rochester, NY 14602; e-mail, lenglund@frontiernet.net; website, http://www.ggw.org/asras.

**JULY 21**

### Cuyahoga Astronomical Association Annual Convention

Club observatory, next to Letha House Park Barn, Chatham Township, Ohio. Event includes a cookout, speakers, and a star party. For more information, contact Bob Wiersma, (440) 779–5852, or Albert Matya, (440) 878–0258.

**JULY 21**

### Moon Landing Anniversary Party

Laurie Beechman Theater at the West Bank Cafe, New York City. Hosted by the New York Chapter of The Mars Society. Celebrate the 32nd anniversary of our first steps on another world and help strategize about exploring the next one. For more information, contact Paul Contursi, 490 Third Street, Apt. 2, Brooklyn, NY 11215; (718) 832–6564; e-mail, pcon@pipeline.com.

**JULY 25–28**

### ALCON — Annual Convention of the Astronomical League

Holiday Inn and FSK Conference Center, Frederick, Maryland. Contact Frank Moon, e-mail, alcon2001chair@aol.com; website, http://alcon2001.homestead.com/alcon2001.html

**JULY 27–28**

### Telescope-Making Contest

Parc des Iles de St. Timothee near Montreal, Quebec, Canada. Hosted by the Societe d'astronomie de Montreal. Contact Yvan Pregent, (450) 377–2493; e-mail, ypregent@vf.cgocable.ca; website, http://www.rocler.qc.ca/caori/orion/english.htm.

**JULY 27–30**

### Island Star Party

Vancouver Island, Canada. Sponsored by the Cowichan Valley StarFinders Astronomy Club. Contact Janet Curley, #12 2121 Tzouhalem Road, Duncan, BC V9L 5J5 Canada; (250) 748–2919 (eve.); e-mail, janetc@islandnet.com or c.v.starfinders@home.com; website, http://starfinders.cvnet.net.

**AUGUST 4**

### Astrophoto Seminar — Putting the Universe on Film

Verizon Building, Thousand Oaks, California. Sponsored by the Ventura County Astronomical Society. A one-day seminar on astrophotography from the best in the field. Speakers include James Foster, George Greaney, Bonnie Walters, Brian Webb, and others. The event will also include an astrophoto display, vendor area, and door prizes. Papers on astrophotography and related topics and speakers for the seminar are welcomed. For more information, to submit articles for the proceedings book, or to present a talk, contact Astrophoto coordinator Dave Holland, (805) 526–4032; e-mail, ravndave@earthlink.net; website, www.vcas.org. ■

**CONTACT**

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to tconley@astronomy.com. Add your events to our online calendar at http://www. astronomy.com.

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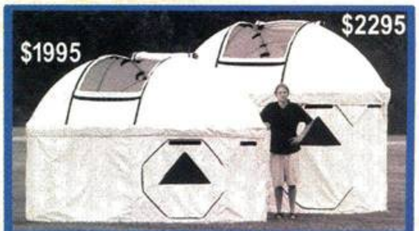

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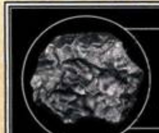

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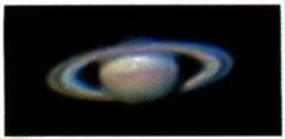

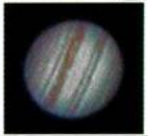

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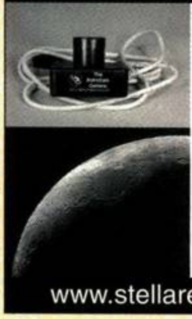

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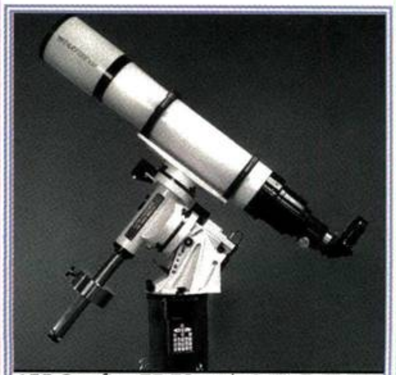

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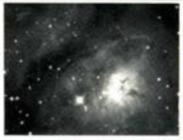

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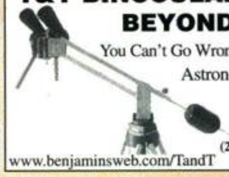
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**Midwest Birding Symposium 2001** is winging its way to Wisconsin! Mark your calendars now for the 2001 Midwest Birding Symposium (MBS). Thursday, August 30 through Sunday, September 2, 2001. Hosted by BIRDER'S WORLD Magazine, EAGLE OPTICS, & the WISCONSIN SOCIETY FOR ORNITHOLOGY. The symposium will offer a varied menu of speakers and field trips of the state, Green Bay is surrounded by wetlands that vary from Lake Michigan shoreline to cattail marsh and sedge meadow. The area lies along major pathways for fall migrants. The theme of Wetlands and Wetland Species will ring through the weekend of activities that will include birding field trips, visits to nature centers , museums and bay cruises. Speakers incluse John Acorn, George Archibald, Kenn Kaufman, Arthur Morris, Peter Stangel and more. The symposium will be held at the Regency Suites Hotel and KI Conference Center in downtown Green Bay. For accommodations, call (800) 236-3330 and request the special MBS room rate of $99. The Green Bay Area Visitors and Convention Bureau can be reached at (920) 494-9507 for lists of alternative lodging. Sponsors include Swift Instruments, Leica Sports Optics, Swarovski Optics, Kaytee Products, Wild Birds Unlimited, National Fish & Wildlife Foundation, WI Dept. of Natural Resources, US Fish & Wildlife Service, the Green Bay Area Visitor & Convention Bureau, Friends of Bay Beach Wildlife Sancturary, and Mosquito Hill Nature Center. Additional information can be found on the BIRDER'S WORLD Web site: www.birdersworld.com. For questions or registration, please contact Jenny Birkel at (800) 558-1544 ext. 245; by fax at (262) 798-6592 or by e-mail at jbirkel@kalmbach.com.

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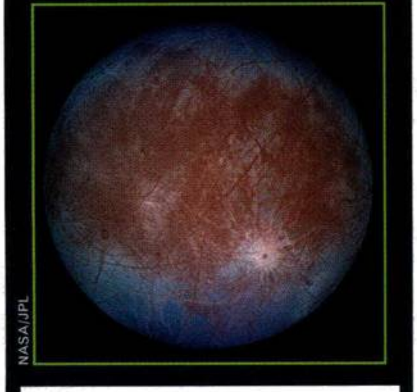
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## AD INDEX

ASM Products .102
ASP .66
Adorama .16, 17
Astro-Physics .102
Astrolink Systems Management Ltd. .103
Astronomics .96, 97
Astronomy.com .27, 106
Astronomy Magazine .105
Astronomyquest.com .15
Astrotec .101
Astrozap .103
Atomic Time .67
Beigle/Bryant Engineering .102
Bethany Sciences .101
CA Bar Ranch .101
Camcor, Inc. .79
Celestron International .18, 19, 73
Coronado Instrument Group .25
Deharpporte Trading Co. .102
Discovery Telescopes, Inc .91
Eclipse Edge Expeditions .94
Edmund Scientific .31
Focus Camera .54, 55
Glatter, Howard .100
Hardin Optical Co. .17, 103
Into the Wind/The Kite Source .102
JMB, Inc .17
Jim's Mobile Industries .93
Kendrick Astro Instruments .94
Krollkraft .101
Le Sueur Manufacturing Co. .91
Let's Talk Stars .31
Lumicon .21
Mag One Instruments .101
Mars Society .31
Marketplace Pages .100, 101, 102, 103
Mayhugh Travel .100
Meade Dealer Pages .12, 13
Meade Instruments Corp. .2, 3, 7, 8, 9, 10, 11, 114
Minerva Press .103
Mountain Skies Astronomical Society .103
New England Meteoritical .101
New Mexico Skies .102
Newport Glass Works .102
Novaspace .100
Oceanside Photo & Telescope .99
Orion Telescopes & Binoculars .32, 33, 85, 113
Parkside Optical, Inc. .94
Peterson Engineering .101
Pocono West Optics .89
Princeton University Press .91
Pro-Tac .100
Rainbow Symphony .100
Retail and Travel Directory .104, 105
Rivers Camera Shop .95
SAC Imaging Systems .101
SCS Astro .100
Science Connection, Inc. .100
Scope City .79
ScopeTronix .101
Shutan Camera & Video .29
Sirius Observatories .103
Skytent International .100
Smithsonian Institution Press .95
Star Hill Inn .100
Star Tek Industries .100
Starsafaris.com .106
Starsplitter Telescopes .103
Stellar Endeavors .101, 102
Surplus Shed .102
Swinburne University of Technology .23
T & T Binocular Mounts & Beyond LLC .103
Tech 2000 .103
Technical Innovations .15
The Telescope Store .67
Travel Quest .101
University Optics, Inc. .103
W H Freeman .31
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# HOT SHOTS

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*AURORAL WONDERS*

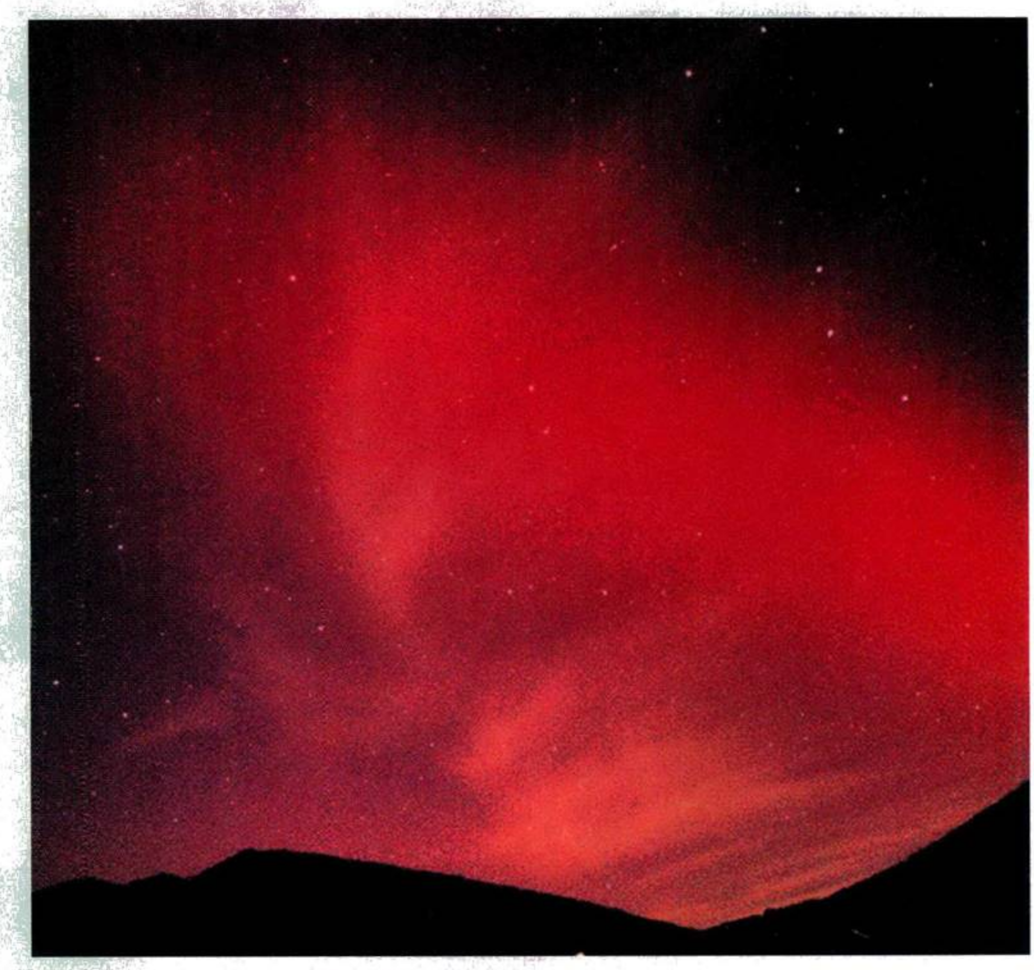
## Fire in the Sky

▶ In some 30 years of observing, I've seen many auroral displays, most located in Ohio and Virginia. And for 20 of those years, my wife, JoAnne, has been exploring the skies with me, searching for as many celestial wonders as we could find. But neither of us had ever come close to seeing anything as spectacular as the auroral display we were lucky enough to witness on Friday, March 30, from our home northeast of Flagstaff, Arizona.

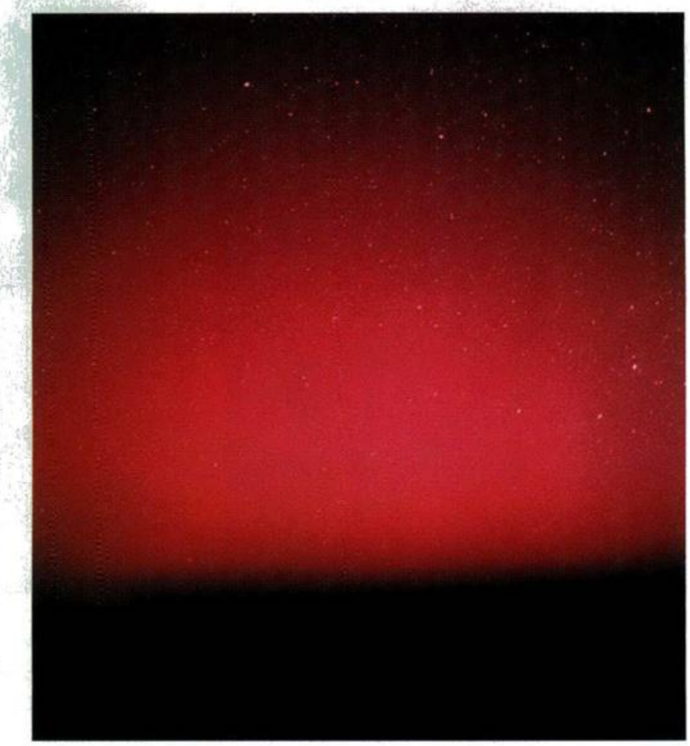
We began watching around 8 P.M. local time, even though we saw no traces of activity. I knew that conditions that evening were extremely favorable for aurorae, due to reports of a coronal mass ejection sending a flare toward Earth. But I never could have imagined just how amazing the sight would prove to be.

Sure enough, by 10:30 P.M. the entire northern horizon was glowing blue-white, as if a large city filled with mercury vapor lighting had suddenly sprung up to the north. At 11 P.M., a spectacular, constantly shifting display of orange rays and curtains covered the entire northern sky, with the rays often reaching about 70° in altitude. It was as if the Cinder Hills volcanoes circling my house had all decided to suddenly become "un-extinct" and fill the sky with glowing ashes.

The blue-white and sometimes greenish glow along the horizon oscillated for hours. A few patches of pulsating, greenish-white aurorae also appeared, 5° to



**Fiery Aurora over France**
**MICHEL BENVENUTO**
(17mm lens at f/3.5, Fujicolor Press 800 film, taken March 31, 2001, from L'Escaréne, France)



**Auroral Spikes over Texas**
**CHRIS GROHUSKO**
(28mm lens at f/2.8, Fuji 800 Superia Xtra film, 30-second exposure taken March 31, 2001)

10° in size, and a flattened one even tilted substantially. It was such an amazing sight that I sent out a message to two different observing e-mail lists. Unfortunately, the orange display in the north was subsiding just about then.

Still, around midnight, a beautiful "crown"-like display appeared near the zenith. With a center about 10° south of the zenith, numerous greenish-white arcs, 10° to 20° long, fanned out to the west, north, and east. Some flickered like candles and changed brightness regularly, and several even connected with the horizon on occasion. This display then morphed into two greenish-white streamers, one coming up from the west, and the other rising from the eastern horizon. These only occasionally connected overhead, but they were both surrounded continuously by large, fuzzy patches of orange.

By this time, the moon had set behind the San Francisco peaks, but its glow mingled with that of the stars and the radiance on the horizon, creating a remarkable sight. This display subsided by about 1:30 P.M. I finally headed inside around 3 A.M., but the bluish-green glow still radiated strongly along the entire northern horizon, much brighter than the brilliant summer Milky Way that had now risen in the east and southeast.

Reports show that many people across the central and western United States and Mexico observed this phenomenon. I have seen only one aurora before that even came close to the one we saw that night, in 1980 in Ohio at Perkins Observatory, while trying to finish

**Venus and Jupiter Pair Off Against the Moon**

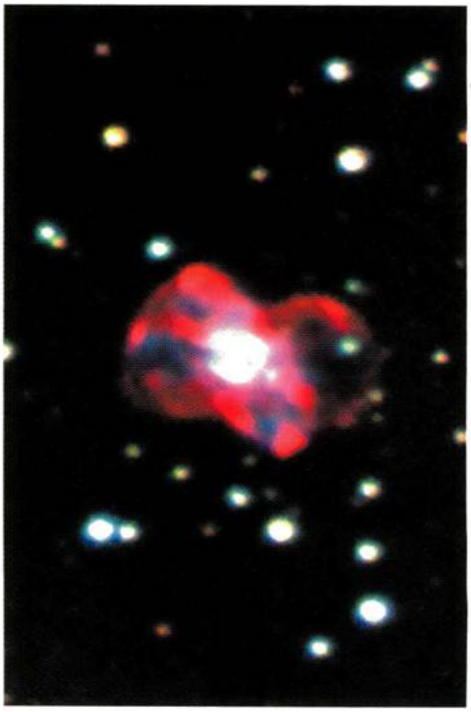
RANDALL WEHLER

(35mm lens at f/2.8, Kodak Elite II 200 film, 5-second exposure taken April 23, 1998)

**Lunar Craters Cassini, Aristotle, Aristillus**

PETER E. SIMSON

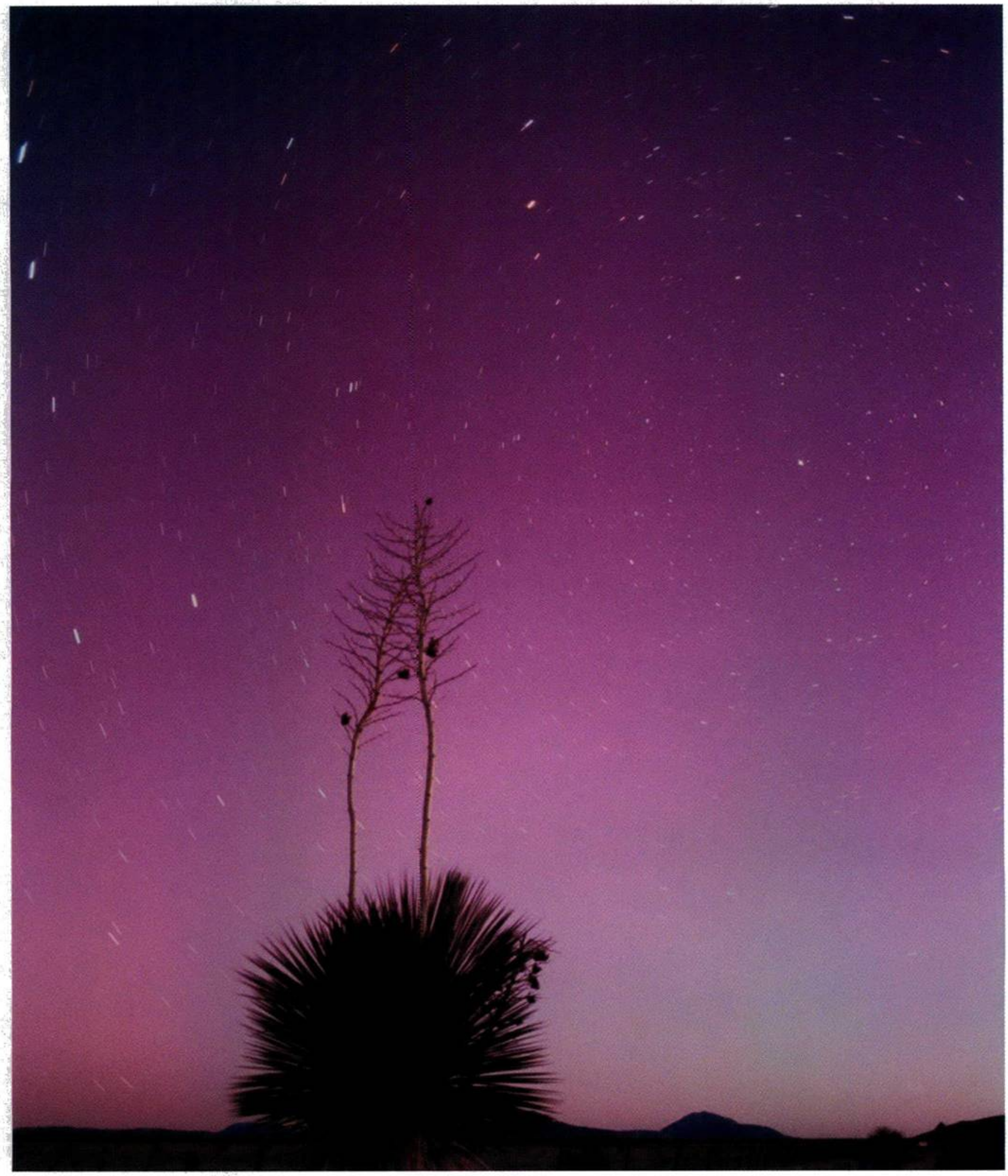
(3.5-inch Maksutov-Cassegrain, ST-237 CCD camera, taken April 4, 2001)



**Planetary Nebula NGC 2440**

JACK AND ALICE NEWTON

(16-inch SCT at f/10, Pictor 1616XTE CCD camera, composite exposure)



**Stars Shine over Northern Lights**

**CHRIS GROHUSKO**

(28mm lens at f/2.8, Fuji 800 Superia film, 20-second exposure taken March 31, 2001, from Hudspeth County, Texas) up a Messier Marathon. And it was clearly also the most spectacular display JoAnne had ever seen. I'll certainly continue to watch when conditions are favorable, but it's difficult to conceive of a show that could ever top this.

---

*Brent Archinal is a long-time amateur astronomer who is working to improve planetary coordinate systems as a member of the U.S. Geological Society's Astrogeology team.*

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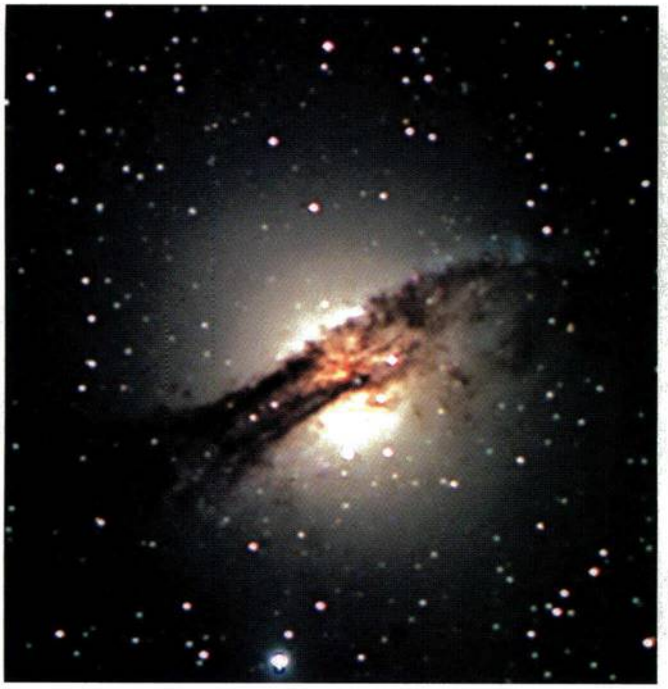
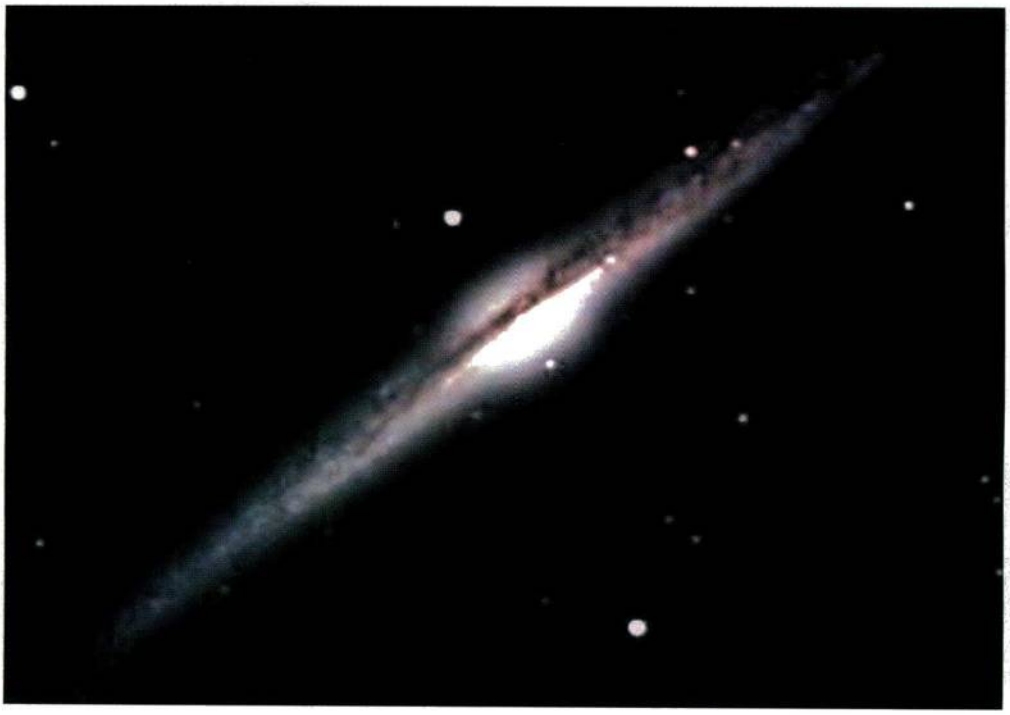


**Centaurus A, NGC 5128**

DAVID HANON

(7-inch f/9 refractor, SBIG ST-8E CCD camera, composite of six 10-minute exposures)



**Edge-On Galaxy NGC 4565**

JOE PETRICK

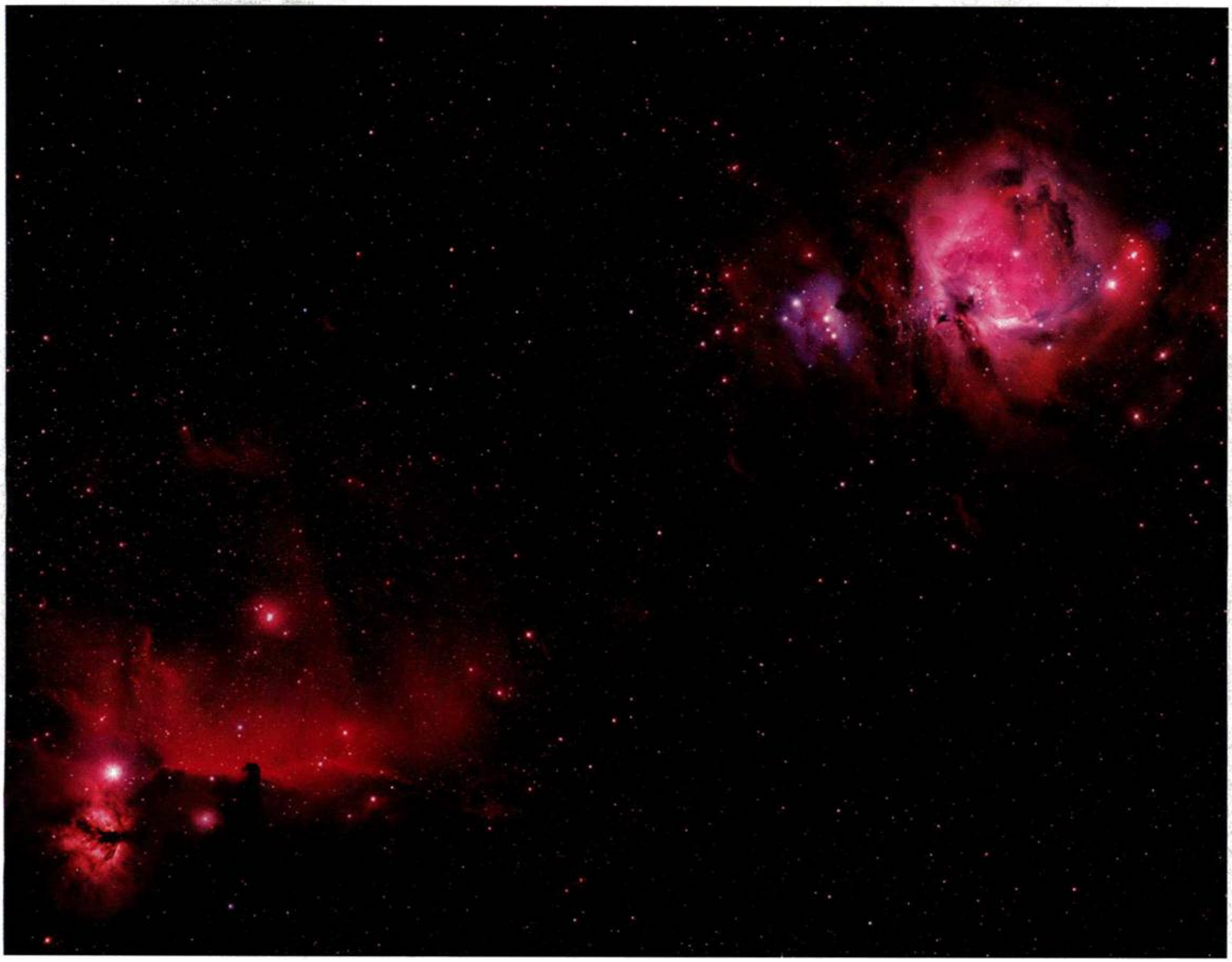
(12-inch SCT, Pictor 416XTE CCD camera, Pictor 616 color filter system, composite exposure)

**Sunset over Monument Valley, Utah**

**JIM BAUMGARDT**

(Sun image made with 10-inch f/5 reflector; composite image using a foreground added in the darkroom)

*This month's best astrophoto*



**Horsehead Nebula Faces the Orion Nebula**

**JASON WARE**

(16-inch f/2.2 Schmidt camera, Fuji 100 ISO film, #92 Wratten red filter, composite of two 15-minute exposures)

Ware used Photoshop to add detailed images of the Horsehead and Orion nebulae made with his 6-inch apochromatic refractor to create this remarkable image.

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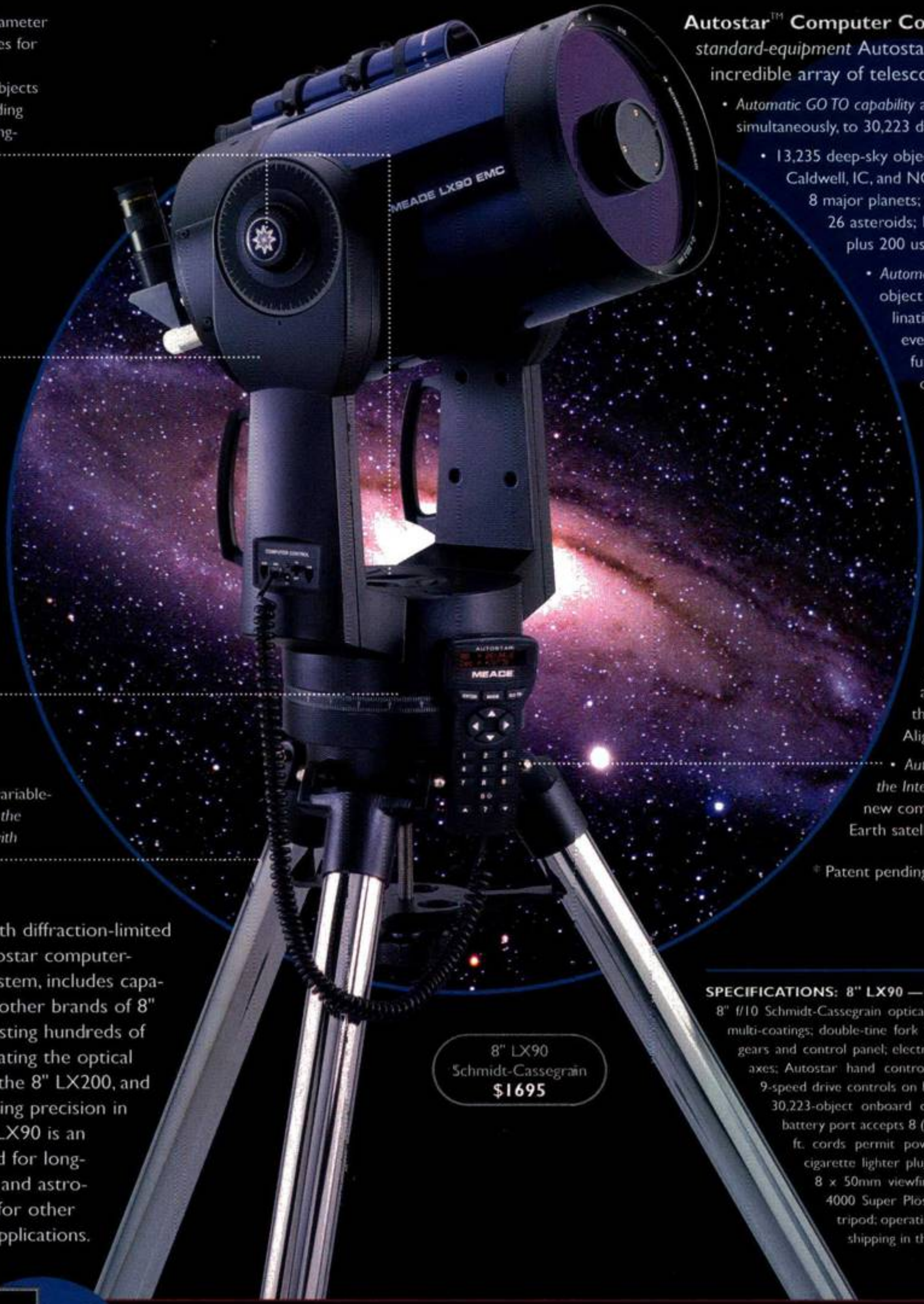

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* Patent pending

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